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Editorial

CERTAIN economic and social aspects of soil conservation are in urgent need of emphasis. The primary objective is to try and secure the best possible permanent use of land and water available. Soil erosion is one of the most sensational forms of soil loss caused by man's misuse of land, and hence has been the main plank on which the need for soil and water conservation has been built up in other countries and is being built up in this country. The prevention of erosion is undoubtedly an urgent need which deserves a place in the very first programme, but it seems necessary to be warned against the danger of anti-erosion practices and work being taken for the entire gambit of right uses of land and water. It is equally necessary to provide against the further misconception that anti-erosion work consists of curing gullies after they are formed and not in ensuring agricultural and other practices that prevent the starting of gullies.

Afforestation on the higher slopes and poorer soils on which pasture and agriculture cannot be safely raised; suitable agronomical usages on cultivable and cultivated lands by putting them under pasture, or under crops adopting such practices as strip cropping and appropriate rotations to impede the speed of run-off of water and help in conserving the maximum moisture and the best texture in the soils; mechanical methods such as gully curing and plugging, small retention dams for holding back the silt and reducing the speed of water and mechanical methods of conserving water on cultivated areas through various forms of terracing and bunding; all these are of great value. But large irrigation schemes with controlled delivery of water for the crop and a well-designed drainage to take off the surplus without damage to the soil are equally important forms of soil and water conservation. It would thus be seen that various practices of forestry, of agriculture and of irrigation that have been evolved essentially for greater sustained production of wealth from lands must necessarily constitute the backbone of programmes designed to stimulate the best permanent uses of land and water resources. The popular misconception that soil conservation is just one new technological trick, which by some magic, will stop all erosion and wasteful losses of soil and water and is confined to that, has to be resisted and contended.

The essence of the movement for better use of land and water seems to consist of an appreciation of the need for it all round, and the promotion of the outlook that land is an exhaustible resource that requires protection, improvement and use according to what it is best adapted for. An integrated approach through the various methods that are now practised with a view to promoting the maximum

good through such co-ordination; and the initiation of a small fund of knowledge regarding the behaviour of the runoff of water under different conditions of rainfall, slopes, soil and vegetable covers and cultivation practice, so as to be in a position to recommend the most economical form of land use for a certain set of local conditions; both these also are necessary. Another factor is the appreciation of the question as a whole by technologists specializing in the different aspects so that the ultimate picture is not lost in the details of specialization.

An overall picture must necessarily include a survey of the natural resources and existing practices of land and water use with the sociological feature. A plan for a better state of things requires a fine sense of what can be achieved and what cannot. With half to one acre of cultivated land available per capita, a cattle population half the human population, and both of them increasing at an uncontrolled and alarming pace, the great urgency for maximum permanent available output of the natural resources and aiming at the optimum human and bovine population that they can maintain at all at a reasonable standard of living needs no emphasis.

The programming of the plan into concrete phases of time and cost and physical achievement is perhaps the most difficult stage of administrative procedure requiring a correct appreciation of executive capacity in a sphere of free enterprise like agriculture. It would be obvious that except for research, demonstration and advisory education, the bulk of the work on cultivated land must be done by the farmer himself. The extent to which new methods and changes advocated are acceptable would largely depend on whether they are feasible, profitable and are communicated in the right way. A programme to be at all practicable must take into account these factors, particularly with reference to the cultivated areas. Wastelands and forests are still largely under State control, and it should be easier to handle them effectively and quickly provided adequate policies, personnel and finances are provided.

The essence of effective soil and water conservation in this country would seem to lie in the review of policies adopted independently on various matters connected with land and water use, and so changing them through, what must necessarily be slight modifications, to fit them into a co-ordinated picture of better use of land and water. Forests, for instance, are by and large inadequate and localized, and the need for better supplies of fuel and fodder and house-building timber particularly in areas of intense cultivation is obvious. Agronomical research has tended to deal with well-known set problems in an environment different from that of the farmer. The machinery for bringing in specific problems of local areas for a quick answer and taking back the answer in time to be of some use is only now being developed through the National Extension Service. The enormous change in responsibility of the agricultural research workers from dealing with problems largely of their own choice to a position where they must answer specific problem of individual cultivators is perhaps not yet fully realized. Agriculture being the only way of living open to a large population and not a competitive profession to which those who are best fitted take to, has endowed property and other legal titles in land with an importance and emotion that is not paralleled by any other form of property. Wide sweeping land reforms are

taking place. The abolition of the intermediary between the State and the cultivator has rendered, among other things, the adequate provision of supplies and credit in rural areas particularly acute. Ceilings in areas of ownership would in its turn provoke difficult question of redistribution and better management. The primary step of consolidation of the holdings of a single farmer to enable him to utilize his water and irrigation resources, manure, cultivating capacity and where necessary, protection of the crops by fencing has made little progress in many States. From the point of view of production that would appear to be the most important change necessary. The need for shaping policies in different departments that deal with irrigation, forestry, fertilizers, better seeds and cultivation practices, land tenure, etc., through concessions, subsidies or other services so as to encourage the best practices in farming is yet to be taken up in a systematic manner.

The questions of costs and finances in introducing and maintaining better practices of soil and water conservation are also frequently misconceived. Except for specialized training and research in a few matters mentioned before there is little that needs to be done for soil and water conservation which is not already the legitimate jurisdiction of the activities of Government as distributed between departments and Ministries. For such specialized work funds have been rendered available as part of the Five Year Plan. Obviously no Government can incur expenditure for which they cannot raise the money, but a review of the standing budget under the various departments and the different personnel that they employ in a specialized manner for their specialized aspects of work would indicate that with effective co-ordination of policies and executive programmes at various levels very considerable progress can be made in soil and water conservation without much extra expenditure. But to effect this there must be an understanding and acceptance of the need for such co-ordination individual or departmental, perhaps with some sacrifice of personal achievement and its consequent loss of publicity; the bulk of soil conservation lies in better forestry, irrigation, agronomy, land tenure, etc. Departmental narrowness or professional jealousy cannot be permitted to hamper the promotion of the maximum benefit that different agencies can secure by adequate co-ordination which will directly benefit the country as a whole.

As the value of land and its productivity increases, increasing finances would be available for its further improvement. This is already true of river valleys where considerable expenditure will be incurred for irrigation, electrical generation, flood prevention and so on. In such cases, better methods of soil and water retention on the higher slopes lead directly to a longer life for the dams and a higher base capacity of power generation throughout the year, and these two factors alone can pay for very elaborate soil and water retention practices. Even in other areas, the assessment of total benefit of beneficient practices in one area on the area itself and areas lower down including the numerous consequential benefits of agricultural improvement are not yet fully developed. The cumulative effect of a greater agricultural productivity in an area leading to developments in other lines such as trade, communication and industries should be obvious, but restriction of total benefits to the cash returns, particularly in the form of taxes in a particular area, is a practice that dies hard.

The Potato in Indian Agriculture

by S. RAMANUJAM

THE National Plan has rightly laid great emphasis on achieving national self-sufficiency in food by increasing production in the country. Besides food, it has also stressed the importance of increasing the production of industrial crops. With a view to securing this all round increase in production, the plan has laid down targets and has proposed methods for achieving them through development programmes relating to major and minor irrigation works, extension of cultivation, reclamation and intensive farming based on the application of research.

In planning for self-sufficiency in food, it is recognized that the aim should be to produce enough food for all in the country, which will be of the right kind consistent with nutritional standards; the plan should also provide for the increase in population, which is taking place at the rate of about 1·25 per cent every year.

According to pre-war world food survey carried out by the Food and Agriculture Organization, India is classified as a low calorie area with an average intake of 2,021 calories per head per day. The *per capita* consumption of food in different countries, in terms of actual quantities and calories respectively, is given in Tables 1 and 2.

It will be noticed from the above tables that apart from the very low intake, a very high proportion of the calories in our diet is derived from cereals; the protein, particularly, animal protein, and other protective foods are consumed in very much less quantities compared to other countries which are more favourably situated with regard to food. Our great dependence on food grains, particularly cereals, is also reflected in the very large acreage, under cereals in the country as shown in Table 3.

About 80 per cent of the cultivated area is under food crops of which 62·28 per cent is under cereals alone; thus, the area available for production of industrial and other protective food crops is very small.

It has been estimated by the Planning Commission that our requirements of cereals in 1956 for the balanced diet, as laid down by the Nutritional Advisory Committee, at 14 oz. per day per adult, will be 52·01 million tons which means the production of an additional quantity of 7·68 million tons. Additional requirements of pulses in 1956 will be 4 million tons. Similar large increases in production will be required for fruits, vegetables, milk, meat and eggs which are also very much in short supply in the country. The present availability of fruits and vegetables is estimated at 1·5 oz. and 1·3 oz. per day per adult respectively. Our requirements of balanced diet, on the other hand, are 3 oz. of fruits and 10 oz. of vegetables per adult per day. The availability of milk is estimated at 5·5 oz. per adult per day as against the nutritional requirement of 10 oz. Similar figures for fish are 0·2 and 1·3. We have little information regarding the availability of meat and eggs; it is, however, known to be low. The above figures indicate the magnitude of the problem of producing adequate quantities of balanced food for the population.

Since our land resources relative to the population are limited, it is necessary to utilize the land to the best advantage so that our requirements in regard to food and industrial crops are fully met. In the case of food, this can be done if the various ingredients of the diet are obtained from sources from which they can be obtained more efficiently and economically. Thus, as regards carbohydrates which are required in large quantities, potatoes, sweet potatoes and tapioca provide them very much more than the cereals per acre.

With a reasonable standard of cultivation and by the use of improved varieties, it is not difficult to obtain an average yield of 200 mds. per acre in the case of potato, and with this yield it will produce three to four times the quantity of carbohydrates per acre as of wheat or rice. Thus, if potatoes

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TABLE 1 — PRE-WAR FOOD SUPPLIES

(Lb. per head per year at retail level)

Country	Total	Cereals	Roots & tubers	Sugar	Fats	Pulses	Fruits & vegetables	Meat	Milk	Wine & beer
U.S.A.	1580	198	145	106	44	20	447	194	426	—
Canada	1401	207	194	103	42	18	215	173	449	—
Eire	1723	277	411	84	35	4	198	125	505	84
U.K.	1338	211	176	110	46	13	249	189	344	—
Denmark	1773	205	249	121	57	4	288	169	548	132
France	1861	283	314	48	29	24	302	147	339	375
Germany	1590	260	387	53	48	4	189	143	352	154
Burma	790	361	62	20	15	26	158	108	40	—
Siam	840	299	101	13	15	37	222	124	29	—
India	651	303	18	33	7	51	81	17	141	—

TABLE 2 — PRE-WAR FOOD SUPPLIES

(Calories intake per head per day)

Country	Total calories	Cereals	Roots & tubers	Sugar	Fats	Pulses	Fruits & vegetables	Meat	Milk	Wine & beer
U.S.A.	3249	887	139	515	502	105	210	524	367	—
Canada	3109	943	177	518	464	81	118	442	366	—
Eire	3184	1205	333	416	393	14	76	329	389	29
U.K.	3005	898	125	465	509	67	87	585	269	—
Denmark	3249	859	220	603	642	16	81	404	390	34
France	3012	1206	247	247	320	100	67	303	222	298
Germany	2967	1117	317	264	528	17	52	399	227	46
Burma	2349	1589	82	103	184	97	62	203	29	—
Siam	2173	1341	200	69	180	114	66	179	24	—
India	2021	1306	37	163	71	210	41	37	156	—

can be produced in larger quantities and consumed in the country, the pressure on cereals will naturally be reduced. This will help in restricting the acreage under cereals and providing more land for production of protective foods in which we have to make considerable headway.

On account of its high productive capacity in terms of calories per acre compared to cereals and its quality as a wholesome food, the potato has played and is playing an important part in the food economy of all the progressive countries. In Germany the area under potatoes is 25 per cent of that under all cereals, in England it is 17·8 per cent, in France 14·0 per cent and in U.S.S.R. 7·2 per cent.

The Bengal Famine Enquiry Commission and recently the Planning Commission have emphasized the importance of subsidiary foods such as potatoes, tapioca and sweet potatoes which give very much higher yields per acre than the cereal crops. However, potatoes have not received the necessary attention in our country. Considering the great part it is likely to play in our country's agricultural economy, the advantages and possibilities of increasing the production of this important crop are set out in the paper.

Importance of Potatoes as a Food Crop

The potato is one of the most efficient of the starch-producing plants. In cool regions with light soils provided with adequate moisture the potato has few rivals as producer of food. Apart from its energy value, the potato has other merits as food. It contains appreciable quantities of protein, minerals, vitamins B and C. It is also a desirable source of food for neutralizing excess of acidity in the stomach since it contains 9 c.c. of alkali per every 100 grams of raw

TABLE 3 — AREA UNDER FOOD AND OTHER CROPS IN INDIA (1952-53)

	Area (million acres)	Per cent of the total cropped area
Group I (food crops)		
1. Cereals	199·79	62·28
2. Pulses	46·66	14·54
3. Potatoes	0·60	0·18
4. Fruits and vegetables excluding potatoes*	4·40	1·37
5. Sugarcane	4·37	1·36
6. Other food crops*	1·65	0·51
	257·47	80·24
Group II (commercial crops)		
7. Oil seeds	27·51	8·57
8. Cotton	15·67	4·88
9. Jute	1·83	0·57
10. Other fibres	0·40	0·12
11. Tobacco	0·79	0·24
	46·20	14·38
Group III (plantations, condiments and spices)		
12. Plantation crops* (tea, coffee and rubber)	1·19	0·37
13. Condiments and spices*	2·46	0·76
	3·65	1·13
Group IV (other crops)		
14. Fodder*	11·17	3·48
15. Other crops*	2·27	0·70
	13·44	4·18
Total cropped area:	320·76	

*These relate to 1949-50 from " Land Utilization Statistics " quoted in the " First Five Year Plan ". The rest of the figures relate to the final estimates of 1952-53 from " Agricultural Situation in India ".

TABLE 4 — QUANTITIES OF DIFFERENT INGREDIENTS PER ACRE

Ingredients	Rice at 10 mds.	Wheat at 10 mds.	Potato at 100 mds.
Proteins (lb.)	68·00	94·00	128·0
Fats (lb.)	4·80	12·00	8·0
Carbohydrates (lb.)	624·00	570·00	1832·0
Mineral matter (lb.)	5·60	12·00	48·0
Calcium (lb.)	0·08	0·40	0·8
Phosphorus (lb.)	1·36	2·56	2·4
Calories (in thousand)	1280·00	1258·00	2584·0

tubers. Assuming that a normal man needs a minimum of 3,000 calories to make good his daily expenditure of energy the consumption of 7 lb. of potatoes a day would satisfy his requirements; this quantity would give him, in addition, all the proteins, iron, vitamins B and C, about half the phosphorus and $\frac{1}{10}$th the calcium he requires. If he drank a pint of milk in addition, he would get sufficient quantities of vitamins A and D and be in possession of a diet nearly perfect in all respects. In fact, the Irish labourers of the last century remained in good health for ten months of the year on a diet consisting of little else than unlimited potatoes and a glass or two of milk.

The quantities of different ingredients of food produced by potatoes in comparison with wheat and rice are shown in Table 4.

The *per capita* annual consumption of potatoes and cereals in some of the Western countries and in India is given in Table 5.

It will be noticed that in most of the Western countries the potato takes almost an equal rank with cereals as a part of the daily diet of the people.

Speaking of the tremendous potentialities of potatoes in the food reserves of the mankind, Nixon in his book " Principles of Potato Production " has remarked that " the part that the potato plays at the present time in maintaining life, through supplying food to the densely populated continent serves to direct our attention to the part it is destined to play as a source of food in our own country (U.S.A.) and in our own continent (America) in the years to come; the famines which normally devastated Europe became much less frequent after the potato was cultivated as a food crop ".

TABLE 5 — PER CAPITA ANNUAL CONSUMPTION OF CEREALS AND POTATOES

Country	Cereals lb.	Potatoes lb.
Germany	305	325
Belgium	496	506
Poland	198	175
Czechoslovakia	435	260
United Kingdom	214	172
U.S.A.	176	142
Austria	322	117
Palestine	362	78
India	365	9

Besides food for human beings, potatoes can be used as feed for livestock.

Industrial Uses of Potatoes

A great variety of products can be produced from the potato such as starch, dextrine, glucose, alcohol, potato flour and a number of dehydrated products such as dried and shredded potatoes. In Germany, where the total production of potatoes amounts to six times that of the United States, 10 per cent of the crop is used in the production of industrial alcohol, starch, dextrine, etc. During the Great War, the potato was a great source of power and food for the German people. According to Wallace, a former Secretary for Agriculture of the United States, "without the potato the Great War could not have been fought . . . Certainly it furnished a great reservoir of power and food for the German people."

Present Position of Potatoes in India

Although introduced into India as far back as the 17th century, potatoes have not made much progress in the country. The present acreage under potatoes is estimated to be about 6 lakh acres which is only about 0·2 per cent of the cultivated area. About 90 per cent of the potatoes are grown in the north Indian plains in winter and the rest in the hills in summer; at the cooler elevations in the peninsula, particularly in the Nilgiris, the crop is grown all the year round owing to the mild climate prevailing there. The potato is not cultivated at all in the plains of south India because of the warmer climate. Table 6 gives the area and production of potatoes in the different States in India.

The average acre yield is estimated to be about 100 mds. per acre and the total production about 19,32,000 tons (about 52

TABLE 6 — AREA AND PRODUCTION OF POTATOES IN DIFFERENT STATES OF INDIA (1952-53)

STATE	AREA IN THOUSAND ACRES		PRODUCTION IN THOUSAND TONS		TOTAL AREA (thousand acres)	TOTAL PRODUCTION (thousand tons)
	In the plains	In the hills	In the plains	In the hills		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Assam	51	19	103	39	70	142
Bihar	97	—	401	—	97	401
Bombay	19	—	89	—	19	89
Madhya Pradesh	11	—	26	—	11	26
Madras	—	20	—	64	20	64
Orissa	14	—	14	—	14	14
Punjab	15	1	78	3	16	81
U.P.	203	14	600	35	217	635
West Bengal	96	4	413	8	100	421
Hyderabad	1	—	2	—	1	2
Madhya Bharat	4	—	8	—	4	8
Mysore	11	—	11	—	11	11
PEPSU	3	—	5	—	3	5
Rajasthan	2	—	2	—	2	2
Himachal Pradesh	3	19	2	19	22	21
Saurashtra	+	—	7	—	—	7
Bhopal	+	—	1	—	—	1
Coorg	+	—	×	—	—	—
Delhi	+	—	1	—	—	1
Bilaspur	+	—	×	—	—	—
Kutch	+	—	1	—	—	1
Tripura	2	—	3	—	2	3
Vindhya Pradesh	3	—	2	—	3	2
GRAND TOTAL	535	77	1769	168	612	1937

+ Below 500 acres. × Below 500 tons.

million maunds). After meeting the demand for seed and deducting losses in storage, the quantity available for domestic consumption is only about 9 lb. per annum per man compared to up to 500 lb. in some of the Western countries. On account of their short supply in the country, potatoes are not used for feeding livestock, or for any industrial purpose.

Problems and Possibilities of Increasing Potato Production

There is plenty of scope for increasing both the area and yield of this crop in the country through well-planned research and development. According to Burns, " given disease-free seed potatoes and suitable manuring, the production of potatoes in the existing area can be doubled ". By breeding superior varieties, it is possible to still further increase the yield and also to extend the area under its cultivation to new regions. To achieve this result it would be necessary to successfully solve the many complicated and inter-related problems of production by scientific research which cover many fields of science. While some of these are short-range problems such as the immediate production of suitable high-yielding varieties for the existing areas, control of major diseases and insect pests, others are essentially of a long-term nature such as the production of varieties for special conditions of soil and climate and those with resistance to diseases and pests, frost, drought, etc. The improvement of the nutritive value and quality of the tubers and the production of varieties for fodder and for industrial uses will still further enhance the usefulness of this crop.

The main obstacles which, at present, stand in the way of increased production of this crop in the country are:

(i) the absence of suitable varieties for the varying conditions of soil and climate in the country,
(ii) the heavy toll taken by fungal, bacterial and virus diseases and insect pests which attack the crop in the field and potatoes in storage, and
(iii) the non-availability of sound, healthy seed in sufficient quantities at the right time and at reasonable prices.

A brief discussion of the above problems is presented below:

Varieties — The potato requires a cool climate for proper growth and tuberization; the greatest yields are obtained in places where the temperatures during the growing season range from 55° to 80°F. Apart from temperature, potatoes are also sensitive to photoperiods, and consequently varieties adapted to different day-lengths have been evolved. Thus, there are varieties which will do well under long-day conditions, short-day conditions and under neutral days; the latter are not sensitive to photoperiod and are expected to do well under all conditions of day-length.

In India, potatoes are grown in the plains under short-day conditions, in the hills of north India under long-day conditions and in the hills of south India under neutral days. On account of their differential reactions to photoperiods, varieties suitable for long-day conditions will not ordinarily be suitable for regions with short days. For this reason, the foreign long-day commercial varieties are generally unsuitable for growing in the plains where short-day conditions prevail during the growth of the crop, although some of them are suitable for growing in the north Indian hills in summer under long-day conditions. It is, therefore, necessary to breed varieties suitable for the different regions in order to obtain maximum yields.

At present, the cultivation of potatoes is largely confined to north Indian plains in winter and the hills in summer and to the cooler elevations of the peninsula where potato cultivation is carried out throughout the year, owing mainly to the favourable climate. It is possible to extend the cultivation of potatoes to regions in central and south India where the winter is milder and shorter by breeding varieties which will thrive under slightly warmer weather conditions. Such varieties will also be suitable for growing as an early crop in the north Indian plains, which is usually planted when the temperatures are a little high.

It will be desirable to spread out the cultivation of potatoes as widely as possible in the country as concentration of potatoes in certain regions leads to glut in these areas and scarcity in others, particularly because of lack of facilities for expeditious transport of this bulky and perishable product over long distances.

Soil relationships — The potato can be grown over a wide range of soil conditions

as the edaphic relationships, generally speaking, are of less importance in limiting yields than the climatic factors of the environment. Nevertheless, the soil factors influence yield, length of time required for the crop to attain maturity, eating quality, keeping quality and the extent of loss from diseases. Loam, fine sandy loam or silt loam soils having deep mellow sub-soils with specially good drainage, are most suitable. The crop requires moist soil conditions at all times, without any tendency for poor aeration on account of water-logging. Soils not naturally ideal for potato production may be modified by cropping and cultural practices as well as by applications of fertilizers and manures and adequate moisture. Agronomic practices leading to the building up of organic matter materially increase yields and lend stability to production; potatoes also respond well to the application of organic matter to heavy soils. It is, therefore, possible to bring more land under potatoes by proper attention to agronomic practices, in areas where less productive crops are at present grown, provided a cool growing season and adequate moisture are assured. Some of the areas which will be brought under irrigation as a result of the execution of the various River Valley Projects in the country may be profitably put under potatoes.

Diseases and pests — The fungal, bacterial and virus diseases take a heavy toll and generally reduce yields. The absence of proper control measures against these diseases becomes almost a limiting factor in the successful production of the crop in certain regions. Most of our knowlege of these diseases is empirical as gleaned from the works of investigators in foreign countries. It is absolutely necessary to carry out an extensive and proper survey of the fungal, bacterial and virus diseases of the crop in the country with a view to determining the relative importance of the pathogens in the different tracts, the extent of their spread, the conditions which favour their inciting epiphytotics and the magnitude of damage they cause.

In the hills of north India, late blight caused by *Phytophthora infestans* is a serious disease, while it is practically unknown in the Nilgiris in the south. It also occurs in the north Indian plains causing serious damage to the crop. *Alternaria solani* which causes early blight is fairly widespread in the plains and in the hills. Late blight under favourable conditions for its spread, causes the rapid death of the plants in a few days causing considerable reduction in yields. The symptoms of the disease first appear as water-soaked patches on the leaves which turn brownish-black and dry up. Early blight causes brown spotting of leaves, which enlarges and coalesces, finally killing the leaves. Bacterial and fungal diseases also cause the wilting of plants in the field and rotting of tubers in storage. A thorough investigation of these diseases will have to be undertaken with a view to immediately discovering preventive and curative measures for their control and ultimately for breeding resistant varieties.

There are similarly many insect pests, such as epilachna beetle, cutworms, white grubs, etc., which take toll of the crop. Mites cause extensive damage to the crop in warmer regions, particularly in the central and western India. Control of these pests will have also to be undertaken for extending the area and increasing production.

There is at present considerable loss of potatoes in the stores. Although in recent years, many cold stores have come into being, they cannot cope with all the potatoes produced in the country. Therefore, large quantities are still stored in ordinary country stores. This results in considerable losses, particularly in the plains, where potatoes have to be stored through summer and rainy weather. Insects, fungi and bacteria cause rottage of tubers, which increases under the unfavourable conditions in such stores; losses up to 50 per cent are not uncommon under the unfavourable storage conditions. Experiments have to be undertaken to devise suitable methods of storage for minimizing the loss.

Production and supply of disease-free seed — Since the use of sound and disease-free seed is imperative for the successful production of the crop, proper arrangements for the supply of healthy seed in adequate quantities should be made in the country. This work is undertaken in the more progressive countries by well-organized Seed Certification Organizations which are responsible for the multiplication and supply of seed to the cultivators under certificates guaranteeing purity and freedom from disease. Such organizations have yet to be developed in our country as

at present our cultivators are faced with a paucity of seed at sowing time; whatever seed that is available is not also of approved standard. The inadequate supply of seed and its poor quality stand in the way of expansion of the area under the crop and the production of high yields.

The primary object of seed certification is to combat virus diseases which take a heavy toll of yield. Certification also provides protection against all other tuber-borne diseases which can be readily detected and eliminated. Further, it is useful in maintaining the purity of varieties.

Virus diseases are caused by ultramicroscopic bodies which are carried by the seed tuber from generation to generation. It is not possible to detect the presence of these bodies in the seed tubers. The only way to detect them is by the disease symptoms which they produce on the growing plants. Although there are number of virus diseases affecting potatoes, only a few are of practical importance in our country. They may be broadly classified as 'mosaic' and 'leaf roll'.

The 'mosaic' disease is caused by a number of related viruses which cause from mild to severe symptoms, such as faint mottling of leaves (inter-locking light and dark green areas on the surface of the leaves) to severe crinkling and distortion of leaves. The plants affected with the 'leaf roll' virus have generally a stiff, erect and staring habit; their leaves are thickened and rolled upwards unlike normal plants which have flat and flexible leaves. The leaf-roll affected plants are generally dwarfed and produce a rattling sound when shaken, thereby showing the brittle nature of the leaves.

The above diseases are fairly widespread in all our varieties and they are spread from diseased to healthy plants in the field by means of insect vectors, known as aphids. The virus-affected plants give considerably lower yields than the healthy plants. The only practical method of control is to grow crops from certified disease-free seed.

There are mainly two stages in the production of certified seed, viz. (i) the production and maintenance of absolutely disease-free foundation stocks and (ii) the large-scale multiplication of these stocks for commercial planting. The former is a specialist's job which involves the initial selection of disease-free plants first by visual observation and later by stringent inoculation tests to ensure the disease-freedom of the selected plants. The latter consists of the multiplication of the seed of these disease-free plants in several stages under conditions of rigid control of virus diseases. The multiplication plots are carefully selected and the crops are inspected a number of times during their growth for removal of diseased plants by well-trained Inspectors. Crops which come up to certain fixed standards are only selected for seed purposes.

In the foreign countries, the foundation stocks are usually maintained by the Agricultural Departments but their further multiplication is done by registered growers in their fields, who are carefully selected by Seed Growers' Associations or firms which control the production and distribution of certified seed. In the United States each of the States handling this work has its own separate organization and its own inspection service and there is no Federal control; they, however, use the grading standard which is set by the Federal Government. In Australia and in some of the European countries also the seed multiplication is done by seed growers with technical assistance from the Agriculture Departments. In Canada, however, certification work is handled by the Dominion Government and they issue all regulations and employ all Inspectors. The inspection service is provided without charge to the growers.

Research in Progress on Potatoes

Research work on potatoes in the country is of comparatively recent date. The Indian Council of Agricultural Research, three years after its coming into being in 1929, financed a scheme for investigations on the physiology and genetics of the crop at Madras. This scheme was soon replaced in 1935 by a potato breeding scheme for north India, located at Simla. In 1943, a potato research substation at Bhowali (U.P.) was set up to supplement the work at Simla and a little later a potato seed certification scheme was also initiated at Kufri (Simla Hills).

Considerable preliminary work was done under the schemes such as (i) the collection, classification and study of indigenous and foreign varieties, (ii) the breeding of some improved varieties for the hills and (iii) the survey of potato areas with regard to the

incidence of virus diseases and the production of disease-free stocks of commercial varieties. However, there remained many problems of potato improvement which could be successfully tackled only by integrated and more comprehensive research on an all-India basis. Realizing the importance of long-term research on this valuable food crop, the Government of India have set up a Central Potato Research Institute at Patna in 1949 with substations at Simla, Kufri and Bhowali; these substations, which were previously financed by the Indian Council of Agricultural Research, were transferred to the Central Potato Research Institute.

As a result of work so far done on potato under the Indian Council of Agricultural Research schemes and the Central Potato Research Institute, some useful results relating to the production of improved varieties, manuring of the crop and control of some diseases and pests have been obtained. Disease-free nucleus seed stocks of improved varieties have also been produced and are under multiplication. The more important results so far obtained are given below:

Breeding Investigations: (i) *Varieties for the main planting in the plains* — Improved varieties, O.N. 45, 1202, 1337, 1360 and 2287 have been selected from suitable crosses between Indian and exotic varieties for the main planting in the plains. They yield 10-20 per cent more than the local varieties and possess vigorous haulms and tubers of attractive shape and size and they are also partially resistant to virus diseases. Some improved selections from inbred generations of the commercial variety *Phulwa*, have also been obtained. These improved selections possess desirable characters such as short stolons, early maturity and large-sized tubers.

(ii) *Varieties for early planting in the plains* — In many parts of north India potatoes are planted in September for obtaining an early crop by November when potatoes are scarce in the market. Three early varieties, viz. O.N. 2186, 2236 and 2253 have been evolved for growing as an early crop. They mature in about 60-80 days and give an average yield of about 100 mds. compared to about 40-60 mds. of the commercial variety *Satha*. These varieties are also expected to yield well under milder winter conditions with short growing seasons in south India.

(iii) *Improved varieties for the hills of India* — Hybrid 8, 9, 12, and O.N. 978 and 1362 have been produced for the hills of north India while hybrid O.N. 2090 has given consistently higher yields than the commercial variety 'Great Scot' in the hills in south India. S. 284, a new selection, has done well in Darjeeling and has shown promise of resistance to late blight.

(iv) *Breeding for special characters* — The Institute is maintaining at Simla and Patna a wide collection of varieties and species related to the cultivated potato. This collection contains valuable characters such as disease and drought resistance, capacity to grow under tropical conditions, high protein contents, etc. These are being studied and utilized in breeding work, for producing improved varieties with the required characters. Seedling selections of a wild species, *Solanum chacoense*, have been found to possess considerable amount of resistance to heat; they are able to grow and form tubers under comparatively high temperatures where the commercial varieties fail to form tubers. The tubers of these selections are also resistant to 'charcoal rot' disease which causes heavy rottage of tubers during storage in the plains.

Suitable crosses have also been made and are under study at Simla for the selection of varieties resistant to virus 'Y' and late blight.

Agronomic investigations — Perhaps, no crop responds as much to proper cultivation and manuring as the potato. Investigations on these aspects carried out at the Institute at Patna and at some regional centres in the other States have given the following results:

(1) Nitrogen is the most important single manurial factor which increases yield. Positive response to the application of nitrogen as sulphate of ammonia was obtained in all the 23 experiments carried out by the Institute, which included different soil types, with and without basal dressing of farmyard manure or green manuring.

(2) The effect of nitrogenous manuring was controlled by cultural practices such as water supply and planting date. Adequate irrigation to keep the soil moist during tuberization is necessary to obtain the maximum effect of the fertilizer. Regarding planting date, early planting (end of October) profited most from the same dressing of fertilizer;

late plantings gave progressively decreased responses.

(3) Application of phosphate fertilizer improved the yield only in 10 out of 21 cases; the response of phosphates was obtained on light sandy soils. In regional trials conducted, so far, superphosphate application was beneficial in increasing yield on red laterite soils at Kanke in Chotanagpur and on light sandy soils at Bihar Shariff, Banaras and Muzaffarpur. Effect of superphosphate, however, diminished with higher dressings of farm-yard manure.

(4) Potassic fertilizer gave positive response in only two cases out of 17. It was, in general, without any effect except at Kanke and Bihar Shariff.

(5) Multifactor cultural experiments showed that earlier planting, closer spacing, large seed size and more frequent irrigations increased yield individually and in combination.

Storage studies — Investigations on the causes of rottage and excessive sprouting of tubers in storage under ordinary country stores indicated that (i) early lifting of potatoes in the plains before the soil temperatures rise sharply, keeps down rottage of tubers in storage; thus potatoes harvested by mid-February in north-east India and by early March in the north-west India keep much better than those harvested during later periods; (ii) there are varietal differences in susceptibility to rottage under storage, (iii) sprouting of tubers in storage can be inhibited by treatment with suitable chemicals like esters of alpha-naphthalene acetic acid.

Induction of sprouting in freshly harvested tubers for their immediate utilization for planting also received attention. Cut tubers of freshly harvested material soaked in 1 per cent aqueous solution of thiourea for one hour before planting germinated in about a fortnight while the untreated tubers failed to germinate even after two months. It is now possible to utilize the seed from the hills, which is harvested in September-October for planting in October-November in the plains by this simple treatment.

Disease investigations — A survey of the diseases occurring in the country was being undertaken besides a study of the more important diseases for devising control measures. The survey has disclosed the occurrence of certain new diseases not recorded so far, viz. 'charcoal rot' (*Macrophomina phaseoli*) causing rottage of tubers and ozonium wilt which causes wilting of plants in the field.

Brief notes on some of the other diseases studied are given below:

(1) *Leaf spot diseases* — These diseases, in general, cause damage to leaves to varying degrees depending upon the nature of the disease and degree of its infection. These include late blight (*Phytophthora infestans*), early blight (*Alternaria solani*) and *cercospora* leaf spot and stem canker (*Cercospora* spp.). Spraying the crop with protective fungicides such as Bordeaux mixture or Perenox about the time the disease is expected to appear and also at later stages prevents the spread of late blight. Large-scale spraying carried out on the cultivators' crop in Patna city area was found to successfully check the disease; the sprayed crops yielded 50-70 mds. more per acre than the unsprayed crop. Early blight and *cercospora* leaf spot and stem canker diseases are also controlled to some extent by spraying the crop with Bordeaux mixture or Perenox.

(2) *Wilt diseases* — These cause wilting and ultimate death of plants in the field and reduction in yield. The more important of these are (i) bacterial wilt and brown rot, (ii) rhizoctonia wilt and (iii) ozonium wilt.

The bacterial wilt and brown rot of potatoes is a serious disease in the Kumaun and the Nilgiri Hills, and it also occurs in the plains in West Bengal, Bihar, Bombay, Mysore, etc., particularly in the crops which are planted with cut tubers. The spread of the disease through cutting implement used for cutting the tubers is usually checked by disinfecting the cutting implements. In foreign countries the cutting implement is disinfected by dipping it in mercuric chloride solution (1 : 500). Experiments carried out at the Institute have shown that denatured spirit can be used with equal effect as mercuric chloride solution. Denatured spirit is cheap, easily available and harmless in the hands of the cultivators.

(3) *Virus diseases* — Experiments conducted at the Institute have shown that leaf-roll infected tubers of the variety *Phulwa*, stored in the ordinary stores, produced healthy plants and gave an increased yield of over 100 per cent over those stored in cold store, which gave rise to diseased plants. Storage of tubers under comparatively high

temperature conditions as obtain in ordinary stores, inactivates the 'leaf roll' virus and this finding has opened up the possibility of controlling the 'leaf roll' virus by suitable thermal treatment of infected tubers.

Investigations on pests of potatoes — A number of insect pests cause considerable damage to the potato both in the field and in stores. A survey of these pests is in progress for obtaining data on their occurrence and relative importance. The following pests have been found to be of particular importance:

(1) *Cutworms* — The larvae of a number of species of moths included under this category damage the crop by cutting of the stems and causing gaps in the field. They also attack the tubers. Experiments have shown that the pest can be controlled by the application of organic insecticides, Guesarol 405, G-205-P and D-025, round the plants.

(2) *Epilachna beetle*—These beetles, which damage leaves, are a serious pest in the hills and occasionally becomes so in the plains. Two species of this beetle have been recorded. *E. ocellata* is found at altitudes above 7,000 ft. while *E. vigintioctopunctata* is observed in the plains and at medium elevations. The pest is effectively controlled by dusting the plants with G-205-P.

(3) *Root-knot nematode* — The occurrence of this pest was not known in India so far; but it has now been noticed to be fairly widespread, particularly at mid-elevations in the Kumaun Hills, Netarhat in Bihar and also round about Shillong. It infects the roots of the potato and also attacks tubers producing pimples on them, adversely affecting the yield and market quality of the tubers. Burning the soil before planting potatoes appears to confer a certain amount of control.

(4) *Potato tuber moth* — This is one of the serious pests of stored potatoes causing heavy loss of tubers in stores. The use of D.D.T., which is now being adopted by the cultivators extensively, has brought down the loss of tubers considerably in recent times. While the use of this pesticide on seed potatoes is harmless, it is likely to be harmful on table potatoes.

(5) *Mealy bug* — This is a new pest not so far recorded in India. It attacks the tubers in storage and can be killed by fumigating the infected tubers with carbon-bi-sulphide. Further work is in progress.

(6) *Insect vectors of virus diseases* — A survey indicated that only two vectors, i.e. *Myzus persicae* and *Aphis rhamnigossypii* group, were responsible for the spread of viruses in the plains. Observations have also shown that in Bihar the vector, *Myzus persicae*, occurs in the potato field only for about a month during the growth of the potato crop as compared to about three months in the western States of U.P., Delhi and Punjab. Again, the size of the vector population is much smaller in Bihar than in other States. This probably explains why Bihar is more suitable for growing seed potatoes.

Growing potatoes from true seed — This is a new line of investigation to explore the possibility of growing potatoes from true seed. Although it is the common practice to grow potatoes from tubers, it is possible to raise crops on a small-scale from true seed. The plants raised from true seed grow well and form tubers. The *Phulwa* variety, which is grown extensively in the plains, flowers profusely, forms berries and sets seed. The seeds from a few plants would be enough to plant one acre of potatoes. The seeds have to be sown in the nursery and the seedlings later transplanted in the field. There should be no difficulty in doing this in the plains as potatoes are grown under irrigation. There are many advantages in growing the crop from true seeds, viz. (i) the crop raised from true seeds is free from virus infection which causes considerable reduction in yield, (ii) the cost of seed (tubers), which forms a big item of expenditure in potato cultivation, will be negligible if true seeds are used, (iii) transport of seed over long distances will become easy and inexpensive; one ounce of true seed will be enough to plant one acre as against 10-15 mds. of seed tubers and (iv) the large quantity of tubers now used for planting will be released for human consumption, if true seeds are used for raising the crop.

Before, however, this practice can be introduced into general practice, a suitable variety, which will give a uniform crop with high yield when grown from true seed, will have to be produced. At present our commercial varieties do not give such a crop from true seed because of their highly heterozygous nature resulting from continued vegetative propagation. But, it is not impossible to produce fairly homozygous

varieties which will give a uniform crop, by scientific methods and this aspect of the work is receiving attention.

Summary

The potato is one of the most efficient of starch producing plants; it yields very much more carbohydrates per acre than the cereals. It has other merits as food as well being rich in protein, minerals and vitamins. It can also be used for feeding livestock and for producing industrial alcohol, starch, dextrine, etc.

The potato has played an important part in the food economy of the Western countries and is full of potentialities for doing so in our own country. The present position of potatoes in India and the problems and possibilities of increasing the production of this valuable crop are described in this paper. A brief summary of the research work in progress on this crop is also included.

Studies on the Growth of Some Grasses and Legumes and Their Associations for Pastures in Bihar

—by B. N. CHATTERJI, S. C. MANDAL & S. J. ALAM

Introduction

IN any attempt to introduce a short duration ley in our rotations in order to reclaim the fertility of our upland soils that are getting impoverished due to continuous grain farming one is confronted with three problems, viz. (i) lack of drought resistance in most of our grasses and legumes of good pasture quality, (ii) short growing periods of otherwise promising pasture plants and (iii) widely divergent growth habits of grasses and legumes that thrive well under local conditions. Normally most of the local grasses at Sabour start withering away from December and by March every blade of grass worth mentioning dries away, unless its green and leafy growth is carried further with the help of irrigation. Again, there are only a few legumes, e.g. lucerne that would grow all the year round. Most of the pasture legumes germinate in October or November and continue to grow till March or April, depending on moisture conditions of the soil. Thus one finds hardly one or two legumes that would keep up good growth for ten months, either from July to April or from November to September. Then, there is the difficulty about getting a suitable grass legume association. An ideal association of a grass and a legume for our pastures should have identical growth habits for each of its components to ensure balanced nutrition to the animals feeding on them and to donate considerable amounts of nitrogen to the soil and improve the aggregation of the soil to the maximum. The grasses that grow well all the year round, in this part of the country are mostly tall growing and hence only tall growing legumes, e.g. lucerne or sweet clover are likely to combine with them. Grasses of short heights, that are adaptable under our conditions, are comparatively few in number and hence legumes, e.g. burr clover, black medic, etc. do not have too many grasses in this state to combine with.

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In a previous paper[2] the authors indicated that after finding out the adaptability and soil binding character of grasses and legumes the next phase of pasture establishment is to work out suitable pasture mixtures. In our country the real need in this field is for a few sets of grass and legume mixtures that would grow for 9 to 10 months of the year and continue to yield fairly good amounts of nutritious and leafy herbage throughout, with little or no irrigation. The succeeding phases of pasture development, e.g. rotational grazing, control of botanical composition of the sward, etc., need only be considered after the second phase is overcome.

Experimental

In 1952 *rabi* (October to March) season experiments were laid out in small plots 9×12 ft. to study the following combinations:

(1) *Dub* (*Cynodon dactylon*) grass plus burr clover

(2) *Dub* grass plus sub clover (Australian)

(3) *Dub* grass plus black medic

(4) *Pennisetum pedicillatum* plus *kalai* (*Phaseolus mungo*) and *senji* (*Melilotus alba*)

(5) *Cenchrus ciliaris* plus lucerne

(6) Flinder's grass plus lucerne and

(7) *Dicanthium annulatum* plus burr clover.

The studies made in these plots related mainly to the growth characteristics of the grasses and legumes and to find out how well they combine with their counterparts. Since the plot size was very small the yield data converted to yield per acre are likely to give somewhat high figures, but in view of duplicate trials in most of the cases and the close agreement between duplicates the yield data calculated per acre should not be much higher than the yield that one would have obtained had the experiment been conducted in much bigger plots, e.g. ½ acre or ¼ acre plots.

A new grass was identified as *Andropogon gyanus* Kunth which was brought to Sabour as a seed mixture along with *Pennisetum pedicillatum* from Nigeria. It was grown on a single $\frac{1}{10}$th acre plot and its yield and growth characteristics were also studied.

In another bigger plot ($\frac{1}{5}$th acre) *P. pedicillatum* was grown in alternate lines with *kalai* (*Phaseolus mungo*) during the rains. *P. pedicillatum* was sown in early June and *kalai* was sown in late July after taking a cut from the grass. The growth of the grass was controlled till the *kalai* crop was one month old. Then the grass was allowed to grow with a small dressing of ammonium sulphate (at 20 lb. N per acre) in September and *senji* was drilled in October with another dressing of phosphate at 20 lb. P_2O_5 per acre.

A number of grasses and legumes were introduced at Sabour from Oklahoma, U.S.A., during winter 1953 and they were sown in small plots in order to test their adaptability to edaphic and climatic conditions of Sabour. The following grasses and legumes were introduced: (a) *Panicum virgatum*, (b) *Sorghustrum nutans*, (c) *Borthriochloa* sp., (d) *Eragrostis curvula.*, (e) *Paspalum dilatatum* (f) *Medicago lupulina*, (g) *Medicago hispida*, (h) *Vicia villosa* and (i) *Lespedeza striata*.

Results

Of all the combinations studied it was found that under Sabour conditions (i) *P. pedicillatum* plus *kalai* and *senji*, (ii) Lucerne and *Cenchrus ciliaris*, (iii) *Dub* grass and burr medic and (iv) *Dub* grass and black medic were found to be better combinations than others. *Dub* grass combined very well with burr clover and black medic. This grass though yielded much less green herbage than *P. pedicillatum* or *C. ciliaris* produced excellent pasture and checked the growth of all pernicious weeds in spite of its low growth form. The ingress of weeds in *Pennisatum pedicillatum* and *C. ciliaris* plots were also of no consequence.

The growth of *dub* grass during the winter months was very poor. During rains it recovered soon after each cutting but during winter months it took a long time to renew its growth, after each cutting, even after receiving a light irrigation. *Dub* grass, growing in association with burr clover and black medic, recovered better than *dub* grass alone. The recovery was hastened by a small dressing of ammonium sulphate. A very remarkable feature of a *dub* grass sward is the suppression of the growth of *motha* (*Cyperus rotundus*) which is the most pernicious weed of the locality during *rabi* season and which has the same growth form as the *dub* grass. The only weed of any importance is *Desmodium diffusum* a leguminous weed. It

TABLE 1 — THE YIELD OF GRASS AND LEGUME IN THE *DUB*-GRASS-BURR-CLOVER SWARD

Number of cuttings	Yield of *dub* grass per acre per cutting	Yield of burr clover per acre per cutting	Total yield per acre per cutting	Remarks
	mds.	mds.	mds.	
1st cutting	70	—	70	No legumes during rains
2nd cutting	50	—	50	do
3rd cutting	45	85	130	In December
4th cutting	—	60	60	In January
5th cutting	30	50	80	In February
Total	195	195	390	During the year

TABLE 2 — THE YIELD OF GRASS AND LEGUME IN THE *DUB*-GRASS-BLACK-MEDIC SWARD

Number of cuttings	Yield of *dub* grass per acre per cutting	Yield of black medic per acre per cutting	Total yield per acre per cutting	Remarks
	mds.	mds.	mds.	
1st cutting	75	—	75	In August
2nd cutting	50	—	50	In October
3rd cutting	50	—	50	In December
4th cutting	30	70	100	In February
5th cutting	—	60	60	In March
Total	205	130	335	During the year

was found to grow dominantly in several pockets though the plant was found to have spread itself throughout the length and breadth of the *dub* grass sward. A few other weeds, e.g. *Scoparia dulucis, Setaria glauca* and *Dicanthium annulatum* were also found growing along with *dub* grass, but their population was not considerable except that of *Dicanthium annulatum.* Two varieties of burr clover and black medic, viz. local and Australian were sown at the same time in the middle of October in two different plots. Local burr clover was the first to germinate, followed by Australian burr clover, local black medic and Australian black medic in order. The local burr clover was ready for first cutting in the 3rd week of November, the Australian burr clover in the 2nd week of December, the local black medic in the 4th week of December and the Australian black medic in the 3rd week of January. The Australian burr clover and black medic were found to be more broad leafed and of darker green colour and yielded ordinarily 25-50 per cent more of green herbage than the local ones. This suggested that if local and Australian varieties of burr clover could be hybridized an early variety of burr clover might be evolved. An attempt was made in this direction by one of the authors (Chatterji B. N.) and a few seeds could set as a result of the crossings.

Of the two associations with legume the *C. ciliaris* and lucerne yielded more green matter than the Flinder's grass and lucerne combinations. Moreover, the *C. ciliaris* and lucerne combination continued to yield green herbage more uniformly than the Flinder's grass and lucerne sward.

Lucerne started to degenerate from the month of June. In the month of July it gave a very poor yield and during the rest of the rainy season it did not grow at all at Sabour. The *C. ciliaris* grew very well during rains. During winter months it yielded much less than in the rainy season, in spite of receiving irrigation every time after cutting. During the summer of 1953

TABLE 3 — YIELD OF GRASS AND LEGUME IN *C. CILIARIS*-LUCERNE SWARD

CUTTING	YIELD OF *C. ciliaris* PER CUTTING PER ACRE	YIELD OF LUCERNE PER CUTTING PER ACRE	TOTAL YIELD PER ACRE PER CUTTING	REMARKS
	mds.	mds.	mds.	
1st Cutting	60	—	60	Harvested in July. Very poor growth of lucerne
2nd cutting	75	—	75	Harvested in August. No growth of lucerne
3rd cutting	45	—	45	Harvested in September. No growth of lucerne
4th cutting	40	—	40	Harvested in October. Lucerne sown in October
5th cutting	50	45	95	Harvested in mid-November
6th cutting	45	54	99	,, December
7th cutting	30	63	93	,, January
8th cutting	25	41	66	,, February
9th cutting	30	60	90	,, March
10th cutting	20	32	52	,, April
		TOTAL	715	During the year

TABLE 4 — YIELD OF GRASS AND LEGUME IN FLINDER'S GRASS-LUCERNE SWARD

CUTTING	YIELD OF FLINDER'S GRASS PER CUTTING PER ACRE	YIELD OF LUCERNE PER CUTTING PER ACRE	TOTAL YIELD PER CUTTING PER ACRE	REMARKS
	mds.	mds.	mds.	
1st cutting	70	—	70	Harvested in July
2nd cutting	40	—	40	,, August
3rd cutting	40	—	40	,, September
4th cutting	45	—	45	,, October. Lucerne sown in October
5th cutting	20	50	70	Harvested in November
6th cutting	10	124	134	,, January
7th cutting	10	112	122	,, March
8th cutting	—	80	80	,, April
TOTAL of eight cuttings from July to April			601	

it continued to yield at 20 to 30 mds. per acre per cutting. Lucerne too yielded on an average of 25 mds. per acre per cutting during this period. Hence, the average yield data during May and June if included in the total given in Table 3, it will be increased to 800 mds. per acre. *C. ciliaris* is an aggressive grass and checks the rank growth of most of the weeds of rainy season and winter months. It is fairly drought resistant and does not die in summer if a very light irrigation is given to it. Its leaves become fibrous and its lower stem gets woody very soon. Hence it seems that this grass is suited to grazing and repeated mowings, rather than to its use as a hay crop.

Flinder's grass, on the other hand, made a poor combination with lucerne. During rains the grass continued to grow well but there was no growth of lucerne. During winter Flinder's grass withered away and lucerne yielded fairly good amount of green fodder.

The other combinations, viz. *Pennisetum pedicillatum* plus *kalai* and *senji* indicated the possibility of a balanced green feed supply all the year round. As explained earlier, *kalai* was sown in the month of July and the growth of *P. pedicillatum* was kept under control for about a month and *senji* was sown in October in the same line as *kalai* after the latter had been harvested

TABLE 5 — YIELD OF GRASS AND LEGUME IN *P. PEDICILLATUM-KALAI-SENJI* SWARD

Cutting	Yield of *P. pedicillatum* per cutting per acre	Yield of *Kalai* per cutting per acre	Yield of *Senji* per cutting per acre	Total yield per cutting per acre	Remarks
	mds.	mds.	mds.	mds.	
1st cutting	100	—	—	100	In early July
2nd cutting	125	80	—	205	In early September
3rd cutting	185	—	—	185	In end of October
4th cutting	50	—	50	100	In mid-December
5th cutting	40	—	130	170	In end of January
6th cutting	20	—	80	100	In early March
7th cutting	30	—	30	60	In mid-April
		Total of seven cuttings per acre		920	

in September. *P. pedicillatum* was found to be a very heavy yielder during the rains but its yield dropped down quite considerably during winter months.

P. pedicillatum is not only a high yielder but it is a very palatable grass as well. It produces seeds profusely and hence its propagation through seeds is very easy. It is also a very aggressive grass and keeps all weeds under control.

The *senji*, in fact, gave three cuttings. The fourth cutting consisted of woody stalks and some green leaves. Two types of *senji* grow well at Sabour, one the white flowered and the other the yellow flowered type. The white flowered plant is more erect and seems to be more drought resistant than the yellow flowered variety. The yellow variety yielded greater amounts of green matter and was shorter in height and spread more laterally than the white flowered variety. This showed that the yellow flowered variety has better pasture qualities than the white flowered variety.

Other combinations did not work well. The growth of sub-clover (which was also grown, but included in the experimental programme) was found to be very uncertain, and hence it is doubtful if without vigorous selection and acclimatization this clover can be profitably used in our pasture mixtures. The yield of *Dicanthium annulatum* ranged from 40 to 50 mds. per cutting during the rains and 20 to 30 mds. per acre during the winter. This grass, of course, combined well with burr clover but in the absence of a systematic record of yield data for this combination the details could not be furnished here.

Andropogon gyanus Kunth. the Nigerian grass, mentioned earlier, yielded in three cuttings a total green matter of 716 *mds.* per acre. Its chemical composition on analysis was found to be as follows:

Crude protein	5·5	per cent
Crude fibre	32·6	per cent
P_2O_5	1·2	per cent
CaO	0·65	per cent

It was found to have greater drought resistance than *C. ciliaris* or *P. pedicillatum* and its growth remained fairly uniform during the period June to December.

Of all the grasses introduced from Oklahoma, U.S.A., *Eragrostis curvula*, the weeping love grass was found to have put up very good growth not only in spring but also in summer. However, during rains its growth was not so good due to the competition of weeds and other local grasses. Under irrigated condition it could tide over the rigours of hot summer months and hence it is likely to prove a good pasture grass in lighter or more aerated soils. Further trials will confirm this point. Of the legumes *Medicago lupulina* and *Medicago hispeda* grew well during winter, along with *Lespedeza striata* and *Vicia villosa*. *Medicago lupulina* continued good growth even up to the end of May. *Vicia villosa* produced a very thick sward but could not recover after a cutting in March. *Lespedeza striata*, though withstood after effects of cuttings in April and May, was found to have a poorer growth in comparison to the growth of the other three

legumes. *Lespedeza striata*, however, continued its growth throughout the year. The plants had small leaves and were more stemmy in nature. The other grasses, viz. *Panicum virgatum*, *Borthriochloa* sp., *Paspalum dilatatum* did not germinate in winter and during rains. *Sorghastrum nutans* did germinate with the first break of monsoons but it flowered and matured very early. The growth was poor and did not seem to be able to compete with the luxuriant growth of the local weeds during rains.

Discussion

The results of these trials indicate that for a dual purpose short duration pasture, a good mixture of a legume and a grass is difficult to work out satisfactorily in Bihar. The encouraging results obtained from *P. pedicillatum-kalai-senji* or lucerne combination suggest that grasses of medium height and perennial nature should make very good combinations with *kalai* and *senji* or lucerne to supply balanced feed to our cattle for about ten months in a year. Hubum clover[2] which under irrigated conditions has been found to grow very well at Sabour till the end of May is likely to be regarded as a better legume than local *senji*. Again, *Cenchrus ciliaris*, which was found to put up more uniform growth throughout the year than *Pennisetum pedicillatum*, seems to be a grass of promise in making a good combination with *kalai* and hubum clover. Thus the present investigations point out that one of the possible grass-legume combinations for our pastures would be *Cenchrus ciliaris-kalai-senji* or lucerne. Since one of the major aims of the authors in these attempts at establishing short duration pastures is to induce better aggregation of soil particles it has always been borne in their minds that the pasture should be established either in *kharif* (June to September) or in *rabi* and not in both the seasons in succession that would result in breaking down of aggregates due to extra tillage operations and it must continue to yield green feed for at least ten months in a year. Much was expected of lucerne, which is a perennial legume, to suit this purpose but its failure to grow during the monsoons set all speculations at naught in this regard. Thus in the absence of an alternate legume to serve the above end a combination of one grass and two legumes had to be devised. This will involve an inter row cultivation for the establishment of *senji* or lucerne after the harvest of *kalai* in September. Such cultivation should, ordinarily, include a basal dressing of phosphate.

A creeping and dwarf grass, such as *dub* grass, well known for its soil aggregating properties cannot combine with any one of our common *kharif* legumes, e.g. *kalai*, *mung* (*Phaseolus radiatus*), soybean, etc. But legumes such as *Desmodium* sp. are likely to combine well with *dub* grass in *kharif*. A careful selection of the *Desmodium* sp. may result in the establishment of a *dub*-grass-*Desmodium* sward of good pasture quality. In the *rabi* season the *dub*-grass-*Desmodium* sward may be subjected to row cultivation and a legume such as burr clover or black medic may be drilled in with a dressing of phosphate. Since burr clover and black medic germinate in different periods it would be better if a mixture of burr clover and black medic be sown instead of either burr clover or black medic alone so that the continuity of the growth of legumes be maintained till the end of March. If the above mixture contains Australian or American (Oklahoma, U.S.A.) black medic, the supply of legume in the pasture may continue even up to the end of May at Sabour. *Lespedeza striata* imported from Oklahoma, U.S.A., continued its growth up to the end of June after which it started to degenerate. However, they persisted to grow during the rains. Further studies should be made to find out how far this legume can combine with the *dub* grass. In Georgia, U.S.A., coastal Bermuda grass, a type of *dub* grass, has been found[1] to be an excellent pasture grass for warmer regions of U.S.A. Such a grass seems to have high potentialities of being utilized as a major pasture grass in India, if properly adapted. *Eragrostis curvula* the weeping love grass, which has just been introduced at Sabour and which is known to be a good perennial grass of tropical Africa, is at the moment being watched with keen interest because of its growth in winter, spring, summer, and rains with sufficient indication for the continuation of its growth in the remaining (autumn) months of the year. If this expectation comes to be true, the weeping love grass will, in all probability, form a good grass-legume association, with one or more

of the legumes, e.g. burr clover, black medic, *Vicia villosa* or *Lespedeza striata.*

Summary

Possibilities of establishing following pastures to fit in the crop rotations in the upland soils of Bihar, for the maintenance of soil fertility, have been indicated:

(a) *Cenchrus ciliaris-kalai-senji* or lucerne.
(b) *Dub grass*-burr-clover-black-medic.
(c) Weeping love grass-burr-clover-black-medic.
(d) *Pennisetum pedicillatum-kalai-senji* or lucerne.
(e) *Dicanthium annulatum*-burr-clover-black-medic.

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Effect of Manurial Treatments on: (iv) Recovery of Nitrogen in Crops

—by A. N. PATHAK

Introduction

SEVERAL methods like nitrifying power, nitrogen fixing power, microbial population and carbon dioxide evolution of the soil, have been put forward by several workers as an index of soil fertility; but the fertility of a soil to crop response cannot be predicted from figures obtained by any of these methods unless we grow the crop itself. Several investigators notably Jensen (1910) and Bonazzi (1915) have reported that the nitrifying power of a soil may or may not be correlated with its crop producing power, but others like Brown (1915-16) and Lipman (1917) pointed out a positive correlation between the nitrifying power of a soil and its productivity. The data of Pathak, Shrikhande and Mukarji (1951) on introgen-fixation, and of Pathak and Shrikhande (1952) on nitrifying capacity of permanently manured and unmanured plots show that the two soils have nearly the same nitrogen-fixing and nitrifying capacity, but when looked to the data of Shrikhande and Pathak (1952) on wheat yield of the two fields it is seen that the manured plot gives higher yield than the unmanured plot. Thus, there appears no correlation between nitrifying power and the yield.

In his earlier studies the author (1953, I-III) has given the effect of manurial treatment on (i) availability of nitrogen, (ii) microbiological population of the soil and (iii) water-stable aggregate and physical properties. In the present study attempts are being made to see the effect of manures on the recovery of nitrogen in crops.

Historical

As early as in 1899 Pfeiffer obtained a recovery of 48·4 per cent nitrogen with potatoes in the first year, 9·8 per cent and 4·3 per cent with rye and carrots respectively in the second year and only 0·8 per cent in the third year. A similar experiment was

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reported by Schulzer (1911) who observed a much lower value than those reported above. In a four-year's experiment, his total recovery was 23 per cent, 43 per cent of this was recovered in the 1st year, 27 per cent in the second year, 16·6 per cent in the third year and 12·6 per cent in the fourth year. From Rothamsted, Hall (1917) reported a 30 per cent utilization of manurial nitrogen by mangels. Toth, Blair and Bear (1941) compared the effects of the nitrogenous fertilisers as measured by the yield of dry matter produced, amount of nitrogen in the harvested crop, per cent recovery of the applied nitrogen in harvested crop and residual effect on the soil. The average recovery in varying manures may be summarized as follows: farmyard manure with lime 50·3 per cent and without lime 42·7 per cent and ammonium sulphate with lime 41·6 per cent and without lime 20·5 per cent.

The recent studies of Bartholomew and Hiltbold (1953) showed that plant uptake of nitrogen from the fertilizer increased in direct proportion to the rate of application. Recoveries in total oat crop ranged from 27 to 54 per cent of the nitrogen applied. The lower percentage recoveries were generally associated with the lower rates of nitrogen application and with the addition of plant residue especially corn to the soil.

Procedure and method of analysis — In order to estimate nitrogen-recoveries in crops from the treated soil in which nitrification study was done, seeds of *Panicum crusgalli* var. *frumantaceum* (sawan) were sown. After germination 10 seedlings per pot were allowed to grow and the rest were rooted out. The pots were kept in pot-house which were frequently watered. In order to study the effect of manures on the growth and yield of the crop, moisture content of the pots was kept constant in all the treatments by adding measured amount of water. Growth of each plant in height was recorded weekly. Colour of the leaves, time of flowering and fruiting in different pots were also recorded. When the plants were dried up, they were harvested along with their roots. Grains were separated out and the weights of grains and straw from each pot were recorded. They were analysed separately for their nitrogen content by Kjeldhal method and the recoveries of nitrogen thus calculated.

From the data in Table 1 it is evident that the different manurial treatments have given better growth of the crop as compared to control. The maximum growth of the plants grown in different treatments is in the following order: farmyard manure > compost > ammonium sulphate > control. These differences are statistically significant. The rate of growth of the plants grown in farmyard manure treated soil was faster than compost and ammonium sulphate treated ones. It was lowest with control. A rapid growth took place up to 4th week of its sowing; after which there was a very slow rate of growth which attained nearly their maximum height up to 6th week. After this period inflorescence were observed to come out of the sheath and fruiting started. Fruits were completely matured and plants were dried up for harvesting after 8 weeks.

General observations revealed that though the plants grown in farmyard manure treated soil were tallest, but the number of leaves was maximum with ammonium sulphate treated soil. Plants grown in farmyard manure and compost were erect and quite healthy, while the plants in ammonium sulphate treated soil were weak and showed lodging. Good vigour and rapid growth of the plants grown in organic manures may be attributed to the production of some growth regulating factor. Breazeale (1927)

TABLE 1 — EXPERIMENTAL RESULTS

(Growth of plants in inches from different treatments)

Treatments	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
Control	2·1	3·5	6·4	10·7	13·0	14·1	14·5	14·6
Ammonium Sulphate	2·2	4·4	8·1	15·1	17·6	19·1	19·8	20·0
Compost	2·1	4·5	9·2	15·8	19·1	21·1	21·6	21·7
Farmyard manure	2·1	4·9	9·9	16·8	19·9	21·8	22·2	22·2

found that the stimulating property of organic matter rests largely in the water soluble organic matter and not in the inorganic compounds that it contains. Bottomlay (1914) in decomposting manure suspected the presence of accessory substances which would play an important part in the nutrition of plants. Shreiner and Skinner (1913) and Mockeridge (1920) have shown the stimulative effect of extracts of soil or manure or other organic substances on plants when added to plant culture.

Plants grown in compost and framyard manure treated soils were light green and the colour turned yellowish after 5 weeks, but the plants grown in ammonium sulphate treated soil were dark green up to the end. In Table 2 below are given the dry matter of grain and straw from the different treatments.

It is observed from the data in Table 2 that there is an increase in the yield of grain and straw in different treatments. The following are the descending order: ammonium sulphate > farmyard manure > compost > control. These differences are statistically significant. Ammonium sulphate treated soil gave nearly twice the yield of grain as compared to the control soil, the values being 16·97 gm. and 8·63 gm. respectively. The yield of dry matter of grain and straw from the different treatments may be correlated to their available nitrogen [PATHAK, (1953(i)]. It is all the more interesting to note that there appears to have a decrease in straw to grain ratio with different manurial treatments as compared to that of control, the maximum decrease being observed with farmyard manure treated soil. Grains and straw from the different treatments were analysed for their nitrogen percentage, and total recoveries of nitrogen in crops were thus calculated. The results are incorporated in Table 3 below.

TABLE 2 — YIELD OF DRY MATTER IN GM. FROM DIFFERENT TREATMENTS

TREATMENTS	GRAIN	STRAW	TOTAL	STRAW/GRAIN
Control	8·63	20·72	29·35	2·40
Ammonium sulphate	16·97	36·97	53·94	2·18
Compost	13·31	29·13	42·44	2·19
Farmyard manure	14·81	31·37	46·18	2·12

It is quite evident from the data in Table 3 that the grains produced in the different treatments were richer in their nitrogen content than in control. Nitrogen content of grains in different treatments is in the following order: ammonium sulphate > compost > farmyard manure > control. The differences are significant. Greaves and Pittman (1946) observed that wheat grown with ammonium sulphate on an average contained 0·6 per cent more protein than did wheat grown on check plots. The control soil produced grains poorest in protein content. There appears a slight increase in nitrogen content of straw also over the control.

Total recoveries of nitrogen thus calculated from the yield data and their nitrogen per cent in ammonium sulphate is twice as much as in control. They are in the following descending order: ammonium sulphate (417·7) > farmyard manure (344·7) > compost (323·0) > control (207·7), the figure in brackets denotes the total amount of nitrogen recovered in crops. The treatment differences are statistically significant. From the amount of nitrogen applied and

TABLE 3 — TOTAL RECOVERY OF NITROGEN BY CROP FROM DIFFERENT TREATMENTS

TREATMENTS	GRAIN			STRAW			TOTAL NITROGEN RECOVERED mg.
	Yield gm.	Nitrogen %	Nitrogen recovered mg.	Yield gm.	Nitrogen %	Nitrogen recovered mg.	
Control	8·63	1·47	126·9	20·72	0·39	80·8	207·7
Ammonium Sulphate	16·97	1·59	269·8	36·97	0·40	147·9	417·7
Compost	13·31	1·53	203·6	29·13	0·41	119·4	323·0
Farmyard manure	14·81	1·48	219·2	31·37	0·40	125·5	344·7

TABLE 4 — RELATIVE RECOVERIES OF NITROGEN FROM DIFFERENT TREATMENTS

TREATMENTS	NITROGEN APPLIED IN MG. IN SURFACE 4 KG. SOIL	NITROGEN RECOVERED OVER CONTROL IN MG.	ADDED NITROGEN RECOVERED IN CROPS %
Ammonium sulphate	800	210·0	26·3
Compost	800	115·3	14·4
Farmyard manure	800	137·0	17·1

from the data obtained for total nitrogen recovered in crops, relative recoveries of nitrogen from different treatments have been calculated. The results are incorporated in Table 4.

From the data in Table 4 it is observed that the amounts of nitrogen recovered in crops over control in different treatments are 210·0, 115·3 and 137·0 mg. which come to 26·3, 14·4 and 17·1 per cent of added nitrogen recovered in crops from ammoniun sulphate, compost and farmyard manure treated soils respectively. Lipman and Blair (1920) found 14·61 per cent recovery of nitrogen in farmyard manure and 28·68 per cent in ammonium sulphate.

Discussion

From the experimental results it is noticed that the yield as well as the quality of the grains and straw as well are affected by the different manural treatments. A rapid growth of the plants was observed with soils treated with organic manures which may be attributed to the stimulating property of organic matter. But, on the other hand, it is also observed that the total dry matter and the recovery of nitrogen in plants are maximum with soils treated with ammonium sulphate. This reminds one of the quality of grains with different manurial treatments. Now looking to the available nitrogen content of the different treated soil [PATHAK, 1953(i)] there appears to be a positive correlation with the yield and the protein content of grains to the nitrogen available. Several investigators like Brown (1915-16) and Lipman (1917) found a positive correlation between the nitrifying power of a soil and its productivity. From the data to which attention is here called, one is justified in the following generalization that while the available nitrogen is perhaps valuable for increased yield of crops, it is, at the same time, equally valuable for the protein content of the grain. The richer the soil, as regards its nitrogen level, other factors remaining the same, the more is the yield and the greater is the protein content of the seed.

Summary

Seeds of *Panicum crusgalli* var. *frumantaceum* (sawan) were grown in soils treated with ammonium sulphate, compost and farmyard manure. It was observed that the rate of growth of plants in farmyard manure treated soil was faster than compost and ammonium sulphate treated ones. The yield of grain and straw in the different treated soils was in the following order: ammonium sulphate > farmyard manure > compost > control. The grains produced in the different treatments were richer in their nitrogen content than in control; they are in the following order: ammonium sulphate > compost > farmyard manure > control. The amounts of total nitrogen recovered in crops from the different treatments are in the following descending order: ammonium sulphate > farmyard manure > compost > control.

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Land Utilization Surveys of Saline Soils of the Bombay State

by J. K. BASU & V. D. TAGARE

THERE are large areas of alkali soils known by general term as 'Salines' along with the cultivable areas in the Bombay State. These lands are highly alkaline and contain excess of salts and difficult to cultivate with normal practices without adopting previous ameliorative measures to improve the lands. Utilization of such alkali lands in the proper way and bringing them under cultivation is a great problem and urgent necessity for the increased crop production. Basu (1950) while dealing with the problems of saline soils in the Bombay State has indicated that generally there are three types of saline soils which are normally found to occur, viz. (i) natural salines, (ii) salines formed as a result of irrigation and (iii) sea-affected or tidal lands known locally as khar or khajan. It has been observed that these alkali soils vary in their degree of sodium saturation, total salts and alkalinity and also in the nature of soil horizons which constitute the soil profile. Further, information on the detailed morphological examination of the soils in the field is essential without which no scientific classification of soils is possible nor is it possible to suggest remedial measures for their proper utilization. With this end in view, soil surveys based on modern genetic method (BASU and SIRUR, 1938) have been carried out in the soils of the Bombay Deccan. Basu and Tagare (1943) have studied the problem of alkali soils coming under the first two groups of natural salines and salines formed due to irrigation exhaustively, and surveyed and classified the alkali soils with a view to finding out their nature and methods of management. They have pointed out in this publication that the causes of alkaline degradation are (i) great aridity or dryness of the climate combined with a great soil depth, (ii) topographic situation which affects the surface soil due to salt washings from the surrounding catchment areas, and (iii) nearness of saline sub-soil water. The soil forming processes leading to alkalization of the profiles have been broadly divided into two groups for the purpose of assessing their suitability for irrigation and cultivation (a) processes responsible for the formation of a compact 'A' horizon, but which at the same time help in the development of a porous and well drained 'B' horizon, (b) processes which develop ultimately the compaction of both 'A' and 'B' horizons, thus bringing into existence the worst type of alkali soils. It has been shown that irrigation or creating a humid condition favouring soil leaching is a prerequisite for reclaiming these soils. The soils in the first group are amenable to management with suitable adjustments of cropping practices, while in the second group special reclamation methods such as application of organic manures or chemicals

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and also provision of suitable drains in extreme cases are necessary. For irrigation purposes soils are required to be examined carefully on the basis of nature and compaction of 'B' horizon and amount of soluble salts.

There are also extensive areas of alkali soils in the Karnatak, and considerable research work was done in studying the nature and reclamation of these soils. Basu and Tagare (1950) have surveyed and studied these alkali soils in detail from the districts of Dharwar, Bijapur and Belgaum and their nature was investigated. They closely resemble the alkali soils of the Deccan but are found to occur irrespective of slope conditions on impervious sub-soil materials. A typical profile in Dharwar district showed a black clayey, cloddy and compact 'A' horizon, an intermediate or transitional 'B' horizon with increasing admixture of yellowish-white clay with lime nodules; and finally yellow impervious clay extending to a great depth. Chemical analysis showed that soluble salts increase till the impervious 'C' horizon is reached while the sodium saturation increases progressively with depth, the 'C' horizon being saturated to the maximum extent with both sodium and magnesium bases. These soils present a serious problem for successful crop growing specially under dry farming conditions. In addition to the methods of reclamation of these soils the problem of soil and moisture conservation is also serious particularly on account of the highly clayey nature of these soils which are liable to severe erosion. Investigations on two typical alkali soils of this kind have indicated that cultural and manurial methods with suitable crops and varying seed-rates and spacings can give fairly good yields of crops. Contour cultivation and treatments to soils, such as sulphur and bulky manures help to improve soil structure and lessen salinity with increased absorption of moisture in the soil which is reflected in better yields of crops.

In the present paper it is proposed to deal in detail the investigations carried out on the third type of saline soil, viz. tidal or khar lands for assessing their suitability for reclamation and crop production. Because of the long coastal line of the State on the western side appreciable areas of the low-lying districts near the sea are periodically flooded. Normally the sea water enters through creeks during high tides and submerges large areas of valuable cultivable lands which would have been otherwise able to produce good crops. These periodic inundations render the land progressively saline and in time completely unfit for any crop. These creeks are usually connected with the natural drainage ways of the outlying lands but no washing of salts is possible during monsoon, as the lands remain free from flooding only for short intervals between two tides. The method adopted to reclaim these lands is by putting embankments or dams with sluice gates to prevent the entry of sea-water but allow the rain-water to go out during rainy season. But where the soil is highly salinized detailed soil surveys and further investigations as to the nature and sub-soil conditions are necessary to ensure good draining conditions for successful reclamation. With this view, typical khar land development projects in Gujarat were surveyed and typical profiles examined at important points to assess their suitability for reclamation and crop production. Results of some typical cases have been discussed below in detail:

Khar lands of the Purna Project — The site consists of about 2,000 acres of khar lands near Navsari in Surat district in Gujarat. The tide water rushing through the river Purna enters the creek and spreads all along the various survey numbers of Jalalpur, Tavdi and Mirjapur villages. This creek also serves as an outlet of a nala about 4 miles in length and having a catchment of about 8 square miles. The lands due to spreading of tidal water for several years have become saltish and uncultivable since long. Soils examined in the area generally show more or less uniform nature and seem to be well drained with definite sandy substratum and comparatively low amount of clay. Morphological examination of a typical profile in the affected areas shows a surface 'A' horizon of a brown silty soil looking blackish due to drying of salts usually sodium carbonate. White incrustations also visible in case of excess of free salts; no concretions; structure generally loose. The second layer 'B' horizon is also silty, looking black due to moisture and harmful salts. The lower layer 'C' horizon is more silty and definitely sandy and slightly yellowish-brown in colour. Lower layers are pure sandy with slight admixture of

silt only. Samples from 5 to 8 ft. were tested by auger. The laboratory analyses indicate that the total salts are very high in all cases but practically uniform throughout the profile even up to 8 ft. and vary between 3·04 to 3·60 per cent. The *p*H values are high round about 8·76 or 8·60. No striking difference in Calcium Carbonate contents the values lying between 3·2 to 6·6 per cent. The mechanical analyses indicate low figure for clay and proportionately high figure for silt throughout the profile indicating that soil being not clayey, the effect of harmful salts can be washed down easily. The clay percentages are between 13 to 21 per cent in the second and third layers while values between 7·25 to 17·50 per cent are frequent still downwards up to 8 ft. deep. The free alkalinity in terms of sodium carbonate is about 0·026 to 0·042 per cent while in some of the other profiles it is uniform and about 0·0053 per cent. Although harmful sodium carbonate is present it can be drained away easily with rainwater and there seems to be no fear of sodiumization of clay or serious dispersion of clay to obstruct the drainage as clay percentage is very low in most cases. The exchangeable bases indicate extremely low exchange calcium up to 3 ft., the figures varying from 1·0 to 8·5 m.e. per cent. The figures are very low as compared to good unaffected soil. The exchange sodium is very much higher from 10·0 m.e. to 18·0 m.e. per cent in lower depths than exchange calcium, the Ca/Na ratio being less than 1 m.e. per cent in all cases. Lack of soluble or exchangeable calcium and excess of exchangeable sodium render the soil unsuitable for plant growth. Since the calcium carbonate contents of these soils are sufficiently high leaching with rain water will diminish the alkalinity and also the exchange sodium if large doses of organic manure are added to soil to improve the land after completely stopping the tidal inundation of salt water by permanent embankments.

Khar lands of Dandi village — The site consisted of about 6,500 acres of khar lands comprising various survey numbers of Dandi village in Navsari Taluka of Surat district in Gujarat. The actual area to be reclaimed measures about 5,612 acres excluding 900 acres of low-lying swamps which Government had decided to dispose off for salt manufacture. The land is subjected to periodic inundation of tidal waters of the Arabian Sea coming from the northern side through creeks at the mouth of the river Purna. The tide water comes every fortnight and spreads over the whole area which otherwise could have been useful for cultivation. Examination of some typical soil profiles to cover the whole representative affected area indicates at the outset that the soil and sub-soil conditions all over the area are practically uniform and contain silty and sandy substratum except in the eastern one-third portion in which case the lower horizons of the soil profiles are more clayey and sticky. Soil profiles in the reclaimable area indicate very similar characteristics as in case of the previous Purna Project, surface layer being brownish silty soil, fairly loose, looking blackish due to harmful salts; the 'B' horizon is more silty with nodules lime concretions in most cases, loose in structure; the 'C' horizon is also silty and definitely more sandy reaching to pure coarse sand below 5 ft. depth. The analytical results indicate 3·08 to 3·88 per cent soluble salts in the profiles with a *p*H range between 7·6 to 8·5, the majority of figures lying between 8·2 to 8·5. Soil being less clayey and more silty is not alkalinized to a very great extent suggesting thereby a very favourable condition for easy reclamation. The soils are well supplied with calcium carbonate 4 to 10 per cent and in lower layers as high as from 10 to 16 per cent in most of the profiles. Clay percentage is low, 25 to 35 per cent while silt is round about 42 per cent in surface layers. The lower layers are sandy. The soils are, therefore, easily reclaimable with simple leaching with rain water as in other case. The one-third portion which contains more clay (above 50 per cent) in lower layers will take more time for reclamation. The layers are very compact and with impeded drainage. The reclamation of this portion will require provision of drains and chemical treatments which may be uneconomic. Otherwise there is no striking difference in other respects.

Khar lands under proposed reclamation lands in Cambay Taluka — The areas commanded by the proposed bunds at Wadgaon, Milli, Tarakpur and Duwaran (Near Mahisagar) were examined in field and soil samples analysed subsequently. It appears that in spite of high salts the soils at

Wadgaon, Tarakpur and Duwaran are well suited for reclamation as they contain porous surfaces and sub-soils and sufficiency of lime carbonate in the profiles. The presence of sodium carbonate, however, particularly in Duwaran soil will require careful handling in initial stages of reclamation when application of large amounts of bulky organic manures will greatly help to counteract the evil effect. The morphological examination of the profile at Milli on the other hand indicates impeded drainage in lower layers and cannot be recommended for immediate reclamation with bunding without further investigations.

Similar typical projects in Amreli district were also examined and reports drawn out as to their suitability or otherwise for reclamation and crop production. After reclamation the crops suitable for the tract can be grown successfully when once the salt inundation is stopped.

The rain water falling over the entire watershed carries with it clay and silt due to erosion and deposits it on the salt land. In many cases the land can be fairly reclaimed within a period of two or three years. In certain cases the soil may be in such a state of salinization that the lands may not improve within a reasonably short period. Here, if the project is big one large sums of money will have to be sunk without the prospect of a quick return. In such cases careful survey and examination of the entire catchment area and analysis of soil profiles from the affected area is most essential before any steps are taken for improvement. Normally soluble salts from the soil are washed out by stages and the time required for this process depends on (i) concentration of salts at various depths of the profile, (ii) texture of the soil and (iii) drainage condition of the sub-soil. The process can be hastened up if there is provision for irrigation; otherwise washing out of salts will depend on the natural rainfall and soil drainage, the latter being amenable to artificial improvements. When the salts are removed the structure of the soil deteriorates affecting the crop-growth to a considerable degree. This is prominent when the texture is heavier. The amelioration can be achieved only by replacement of exchange sodium and magnesium of the clay-complex by exchange calcium. Application of sulphur, organic manure, gypsum, etc., is essential to bring about these changes rapidly, and suitable doses must be worked out by field experimentation on different types of saline soils. When the structure is restored better crops with considerably higher yields can be obtained.

It will thus be seen that survey of these alkali (khar) lands is very essential to assess their suitability for reclamation before any definite measures are taken to stop the sea-water inundations. Test surveys are, therefore, important in Soil Conservation Programmes for land utilization where vast areas of alkali lands are to be brought under cultivation.

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An Investigation of the Alkali Soils in Gujarat—Preliminary Report

—by R. K. SHAH & A. M. TRIVEDI

AN expedition was undertaken under the auspices of Gujarat University to make a preliminary investigation about the desert areas in Gujarat. The expedition was under the leadership of Dr. K. R. Ramnathan of Physical Research Laboratory. (Seven persons left on 14th June 1952 for Zinzuwada, one of the starting points of the desert.)

General Description

The area appears to contain quantities of iron sulphide, gypsum, common salt and other soluble salts. The portion investigated was on the border line of the desert, rather than the area of the desert itself. The area contained a number of islands called ' Bets ' consisting of small hamlets in the comparatively more productive lands in the belts of the rivers, Benas, Rupen and Saraswati. The crops taken are wheat, juwar and cotton. The climate is warm and the rainfall is reported to be scanty. The colours of the soil appear to be varying from place to place from light gray to brownish black in some parts.

Chemical Investigation

The analyses of the various samples are given in appendix 'A'. One of the sources of salts appear to be rivers, which discharge their effluents annually in the area. Analysis of the water of rivers from time to time with the estimation of the volume of the water involved would indicate the amount of soluble salts traceable to this source.

Six samples of water examined showed that they are highly saline and by ordinary standards of judgement they cannot be considered suitable for domestic or irrigation purpose. If better sources of potable water cannot be discovered in the area, methods will have to be devised to purify existing supply of water. Attempts will have to be made if ionic exchange in conjunction with lime treatment can be utilized to purify the water supply.

Twelve samples of soil were also brought for study. Six of them were from a profile of virgin land. All the soil samples were subjected to careful examination in the laboratory. It would be premature to draw any conclusion from our small study, although the results obtained show that most of the land is reclaimable if sufficient amount of irrigation facilities are provided. Washing and chemical treatment would be of advantage. The salient features brought out during chemical examination are that the soil has a *p*H of about 8·2; and contains a small percentage of clay; the accumulation of alkali is not very high. The soil contains sufficient lime and the adsorption complex contains less than 15 per cent exchangeable sodium. Quantity of gravel is high although the size of the gravel is below 1 cm. Gypsum crystals and lime nodules are visible in some of the samples.

General Discussion

According to A. A. J. de'Sigmond[1] the first phase in the alkalinization of the soil is connected with the accumulation of alkali salts which may (i) inherently be present in the soil itself due to past geological history, or may be due to (ii) discharge of sea or river water in the area, (iii) effect of desert wind working as a career of salt particles.

The second stage in the formation of the alkali soils is the alkalinization of the soil adsorbing complex. Formation of sodium complex makes the soil highly dispersed and impermeable. The better quality of soil always adsorbs more water than bad soils. If an impermeable alkali soil is converted into a permeable soil by treatment with soluble calcium salts, sodium comes in the filtrate instead of calcium. On the other

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hand if a good garden soil is treated with sodium salts, impermeable alkaline soil is obtained. The reaction is a simple base exchange between the sodium cation of soluble salts and the adsorbed cation calcium of original alkali free soil.

The next step consist of washing out the excess of alkali salts by natural leaching process. The adsorptive complex, however, does not change and hence the soil cannot be reclaimed merely by leaching.

The fourth phase consists of the degradation of alkali soils (which the Russians call solodization) after a large amount of sodium salt has been washed out. Further action will result in partial hydrolysis of the adsorbed sodium cation and the adsorptive complex becomes more and more unsaturated. The *p*H falls below 7 and the adsorptive complex is free from exchangeable sodium. The problem of reclamation of alkali soil must be attacked after determining the extent of alkalinization. About 0·15-0·20 per cent of salt content can be regarded as a possible limit after which the first process should be the washing out of the soil. Sources of water, if necessary, by deep borings must be found out. After the salt content is reduced to 0·15-0·20 per cent treatment with calcium carbonate and organic manure will result in changing the nature of the soil complex. Calcium carbonate is insoluble but if enough farmyard manure is present at the same time, the carbon dioxide generated will produce soluble bicarbonate, from which calcium can be easily exchanged with sodium of the complex. The incorporation and solution of calcium carbonate is a very slow process and the investigation should be carried out for a number of years.

Conclusion

In the first place attempt should be made to collect the past history of the desert, as discovered by different workers particularly of the Geological Survey of India. A small economic survey of the present utilization of the land resources should also be made. Samples from suitable sites, in light of land utilization survey, should be obtained. Profiles will have to be examined and samples up to six feet should be collected. The analysis of the different soils should be correlated with each other. Only when a number of careful maps containing above information are prepared, at definite intervals, it should be possible to tackle the main problem, as to whether the desert advances or not. According to Holland and Christie[2] the main source of the salts in the Rajputana desert is the wind borne sand particles. When sea water evaporates calcium salts are precipitated first followed by NaCl. Therefore, in the salt beds in Rajputana formed mainly by wind borne sand particles containing salt, the proportion of Ca : Mg is much greater than in sea water. If this hypothesis is correct, the proportion of Mg : Ca should be greater in Cutch desert as compared to sea water. Examination of Ca : Mg ratios at different sites in the Cutch desert should serve to indicate how far this hypothesis is correct.

In view of further investigation, another expedition was arranged under the auspices of the Gujarat University by Dr. A. M. Trivedi, Mr. J. C. Vora and R. K. Shah in June 1953. Mr. Patel of Agricultural farm, Marij, accompanied on the tour for part of the programme. The following districts were covered, Marij, Sami, Gochnath, Radhanpur, Santalpur, Piperala, etc.

About a hundred samples of soil, 25 samples of water and a few samples of local plants were collected. These samples are under examination in the laboratory, at M.G. Science Institute, Ahmedabad.

The samples of soils will again be collected this winter from the different sites from the Cutch district, from where the original samples were taken.

Another expedition on about 4th January 1954 is likely to be undertaken at the instance of Gramodyog, GANDHIASHRAM, Saharmati, Ahmedabad, who are making the Sanatan-Soap from the local deposits of Oos. The object of this expedition is to survey the Oos deposits in some parts of Gujarat.

We are thankful to Dr. K. R. Ramnathan for encouragement and Dr. C. C. Shah for discussion. Mr. J. C. Vora helped us in our analytical work.

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APPENDIX 'A$_1$'

No.	Spotting of place	Soil colour	pH	% Stones gravels particles 2 mm.	% Clay Beaker method	% $CaCO_3$	% Total soluble salts (Conductivity method Sp. Cond × 250)	M.E./100 g. Soil: Exchangeable Ca Mg	M.E./100 g. Soil: Exchangeable K	M.E./100 g. Soil: Exchangeable Na	% N	% Humus
A	About 1½ miles from Santalpur on Railway Lines. Depth 0-10 cm. where Dise line ends	Light-brown	8·4	35	3·39	5·082	0·0548	6·3450	0·000	0·523	Nil	0·044
B	Do 1 ft.	Brown	8·3	51	4·29	3·177	0·790	—	—	—	Nil	0·000
C	Do 2 ft.	Brown	8·4	26	8·29	3·366	0·362	5·7960	1·430	0·652	0·014	0·212
D	Do 4 ft.	Dark-yellow	8·7	43	10·00	4·130	0·350	3·3450	—	0·260	0·008	0·301
E	Do 6 ft.	Grey-yellow	8·6	45	16·21	11·120	0·359	—	—	—	0·004	0·067
F	Do 7 ft.	Grey-yellow	8·2	37	20·60	11·120	0·509	6·9700	0·854	0·326	0·0055	0·117
G	Sample at Railway hill opposite new Rly. line extension in desert. Depth 1. ft. 6 in.	Brown	8·6	25	41·22	5·242	4·627	—	—	—	0·015	0·433
H	From upper strata of hill Clay Gypsum strata	Light-brown	8·5	16	1·47	5·719	1·880	7·2320	1·641	0·261	0·009	0·107
I	Soil at border line of desert near Zinzuwada near East Gate. Depth 5 in.	Brown-black	8·3	29	13·57	7·625	3·298	3·5330	2·740	0·228	0·011	0·463
J	Clay from well in middle of Runn (with shells). Depth 20 ft.	Grey	8·0	26	4·77	22·560	16·950	—	—	—	0·003	1·070
K	Sample from Piperala salt well. Depth 20 ft. Water sample is taken	Dark-grey	8·3	37	18·75	35·420	11·700	—	—	—	0·013	1·106
L	Sand sample that migrates due to wind during day time at dist. 1 mile from Piperala	Dark-brown	8·2	16	38·14	13·020	12·800	7·3904	1·221	0·523	0·024	1·049

—Determinations not carried on.

APPENDIX 'A$_2$'

WATER ANALYSIS

Spotting the source — Date & time of collecting samples	Total solids	Chloride	Sulphate	Calcium	Magnesium	Alkali metals Na—K as Oxide	*p*H	Alkalinity as $CaCO_3$
	P.P.M.	P.P.M.	P.P.M.	P.P.M.	P.P.M.	P.P.M.		P.P.M.
At Zinzuwada; *Vav*—used both washing &. Potable. Depth 100-120 ft. (14th June 1952)	900	223	82	150	39	400	8·4	366
At Zinzuwada; Boring used for washing. Depth 300-350 ft. (14th June 1952)	1,560	680	25	38	11	1,004	8·0	296
At Solanki-Wasara—Pool near temple. Depth 15 ft. (14th June 1952)	2,560	1,319	180	96	20	1,440	8·0	279
At Solanki-Wasara — well behind temple. Depth 20 ft. (14th June 1952)	2,600	1,224	263	80	31	1,460	8·5	266
At Piperala — Salt Extraction Well	2,50,400	1,47,680	4,301	20,703	—	—	7·9	109
At Radhanpur — Mr. Kama's Home well. Depth 20 ft.	810	266	33	35	40	520	8·3	520

Notes, Correspondence, News, Etc.

PLANT BREEDING IN SOIL CONSERVATION

PLANT BREEDING HAS AN IMPORTANT ROLE to play in soil conservation programme of a country. The cost-benefit ratio, which plant breeding can claim, stands no comparison with any other branch of Agricultural Science. Most of the plants investigated so far have responded beyond expectation. The great advantage of the breeding programme is that, once the synthesis of the desirable characters has been achieved practically no further expense is to be incurred for several years to reap the advantage, till a better type is evolved. Moreover, with regard to the personnel and equipment both the capital and overhead expenses are reasonably low.

A plant-breeder working in a soil conservation programme will have to consider specially the characters responsible for (i) checking soil erosion, (ii) drought resistance and (iii) maintenance of soil fertility, in addition to the desirable characters for which the plant is grown. His ideal would be to promote the yield and introduce the soil-conserving characters in the plants.

In nature plants grow under different ecological conditions where climatic and edaphic factors vary considerably. They are well adapted to flourish in those conditions with specialization in physiological and morphological characters. From the view point of soil conservation we can broadly consider the plants grown under different conditions separately as follows:

(i) Crops in cultivated fields,
(ii) Permanent grass lands,
(iii) Forests, and
(iv) plants of arid and semi-arid regions.

Their problems are different from one another and it is desirable that their breeding programme be tackled separately preferably in different experimental stations located in those regions.

The technical procedure to breed an improved type of plants is more or less the same for all types of plants. With regard to any particular plant, several types are met with differing in morphological, physiological and other characters. *Collection* of these different types of the plants, based not only on morphological characters but also on their physiological requirements, from different parts of the country and abroad is the basis of all plant breeding programme. The greater is the ' gene ' fund the better chance a breeder has to achieve his goal. The collected types are then raised under the conditions where the improved type of the plant will be grown later. *Selections* are made from these collected types, giving better performance of the desired characters in which the breeder is interested. Many of these selected types by themselves may give better performance than the local types and thus can directly replace them. But generally the desirable characters in which the breeder is interested are found distributed in different types. By repeated *hybridization* and *selection* the ideal plant is synthesized step by step, but once the goal is reached all that is to be done later is simply to propagate it to earn the dividends of all the past outlay.

Hybrids having the desirable characters of the parents can be profitably utilized in plants propagated by cuttings and most of the horticultural and forest plants have this advantage. In plants like maize some of the hybrids are vigorous yielders and have shown great increase over the parents and there is a possibility of utilizing the *hybrid vigour* in many plants.

The gene fund of the breeder continually increases year after year from new plants collected from different parts. In addition, new characters continue to appear in his culture by *mutation* at a very low rate. The rate of incidence of new characters can be boosted up by treatment with x-rays, ultraviolet rays and some mutagenic chemicals, and a mutant with any advantageous character is an additional building stone. Plants with new characters also appear due to *chromosome doubling* as a result of treatment with chemicals like colchicine. Many of these plants are more desirable and have replaced the parent stocks. This treatment holds a great promise for horticultural and

forest plants. But the possibility of chromosome doubling of sterile hybrids of specific and generic crosses is much greater. Such wide crosses are made to transfer desirable characters from one plant to the other but even if the hybridization succeeds most of them are sterile. Doubling the chromosome of the sterile hybrids makes many of them fertile and the new plant thus obtained often combine several desirable characters of both the parents.

Collection of plant types is the basis of plant breeding for all plants varying in habits and habitats. But the steps the breeder will take to build up his type will greatly vary. Increased yield being the ultimate goal, a breeder concentrates on characters which directly contribute to this end, as in case of cereals, on the number of ears, per plant number of grains per ear, size of each grain, etc ... He also works with another set of characters which are indirectly helpful, e.g. those responsible for disease resistance and minimized loss in yield due to infection. A breeder in a soil conservation programme will not only be interested in increased yield but also in characters which will lessen erosion of soil, increase drought resistance, etc... It is known that erosion is minimized by a vegetative cover on the soil and by an efficient fibrous root system which binds together the soil particles. Some drought resistant varieties of plants are most effective in water conservation. A quick branching, high yielding, drought resistant variety with a spreading fibrous root system would be desirable type of crop and forage plant for soil conservation. In case of the cultivated legumes, their capacity to fix nitrogen and recoup soil fertility, would be additional requirements. There are, of course, several other characters to be considered and the extent to which efficiency even in these basic characters are necessary will greatly vary with soil condition and the crop. For most of the crop and forage plants we already have these desired characters whose efficiency will have to be tested for breeding. Systematic collection of types growing under different agro-edological conditions will be extremely profitable.

In the grasslands, grasses and legumes growing together are most efficient for soil conservation. Grasses should have an efficient fibrous root system and yield plenty of vegetable matter for the growing animals. Besides hybridization and selection, wide crossing followed by chromosome doubling offers a great opportunity in grass breeding. The legumes by fixing atmospheric nitrogen will help to maintain the soil fertility and by their spreading branch system will minimize erosion. Grasses like Bahia grasses and legumes like kudzu vines are already being favoured for soil conservation work and there is no reason why we cannot expect better types through a breeding programme.

Breeding of perennial plants, specially those of forests, has been practically neglected mainly for the time-lag involved in such a project. Unless a man is lucky, he does not see his plants craming up in his life time. Even with the large perennial forest plants promising results have been obtained in Sweden and other places where systematic investigations have been undertaken.

The plants of semi-arid and arid region could only interest workers in soil conservation though pine-apple and sisal varieties are now being profitably grown in some of these regions. It is expected that breeders will play a great role in this field, by offering better plants for soil and desert reclamations.

The greatest handicap for breeding a better variety of plant is the time factor-collection, hybridization and selection take several years before the breeder is ready with his improved types to hand them over to the agronomist or the forester for better management of the soil. But his requirement in personnel and equipment is the minimum possible and his result offers a great prospect. Unless the breeder begins to work ahead of others in a soil conservation scheme he faces up to great handicaps and in all soil conservation schemes he should be called upon early to shoulder his responsibility to make it a success. It is hoped that adequate attention will be paid in India for breeding plants specially suited to meet the requirements of soil conservation.

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FLOODS FROM THE CRUMBLING HIMALAYAS

THE YEAR 1954 HAS WITNESSED SOME OF THE worst floods ever recorded in history. The waters of almost all the Himalayan rivers in

the North-Eastern India have been raging with great fury, bringing in their trail untold human misery, devastation of crops and loss of human life. The Assam valley is threatened to be engulfed by the waters of the Brahmaputra and its tributaries. In North Bihar, not only the Kosi but all the tributaries of the Ganges have converted this most fertile tract into an expansive sheet of water. In the eastern U.P., the Rapti, the Ghagra and the Gandak rivers have been causing havoc in about nine districts. The erratic behaviour of the Brahmaputra has been further aggravated by the change in topography caused due to seismic disturbances in 1950.

The Government of India have recently set up a Flood Control Board to deal with the matters relating to policy in connection with floods and flood control measures, and to draw a comprehensive plan for flood control. In addition, there will be two Major River Valley Commissions, one for the Ganges and the other for the Brahmaputra.

The main intention in writing this paper is to focus the attention of these bodies on a matter which may, perhaps, have not received as much attention as it deserves. By and large, in dealing with any problem connected with floods, emphasis is generally given to " Controlling the Flow of Water ", e.g. construction of detention reservoirs as a measure of flood control. The problem of floods in North-Eastern India is somewhat different. Here it must be pointed out that these floods have their origin not so much in the uncontrolled flow of huge quantities of water from the Himalayas down the plains, but more in the uncontrolled movement of silt washed down from the steep slopes of these mountains. It has resulted in complete blocking of the drainage lines and is threatening to disturb the whole topography of this region. The permanent solution to the flood problem here would thus lie in " controlling the movement of silt " rather than " controlling the movement of water ". It is this view point that has been analysed and elaborated in the paragraphs that follow.

The geography of the Himalayan mountains and the plains lower down tells us of the " sedimentary " formation of the former as different from the igneous and amorphous formation of the peninsular India. It also tells us how the alluvial plains have been formed as a result of continuous erosion of the Himalayan mountains. On account of the sedimentary formation, these mountains yield much more easily under the erosive action of water. It is by the gradual process of erosion and silt deposit that the Gangetic and the Brahamputra plains have come to exist. Washing of silt from these mountains, its transport through the various drainages and its subsequent deposit are natural phenomena which we cannot escape, as there must be rains, the Himalayas must crumble and the accumulated load must move forward with water as far as it can. It is necessary to recognize this fact and its effect on the topography of the country as without it no plan of flood control can have any lasting results.

What happens when the floods come from year to year ? The silt selective character of flowing water is a matter of common knowledge. When in velocity in the upper reaches of the catchment it picks up boulders, debris and big particles of sand. Lower down the valley, as the gradient becomes flatter, it goes on depositing its load. The deposit may take place either in bed or on banks where the water is comparatively still or in the countryside where it may find its way during high floods. If nature were allowed to take its own course, the bed of the river would rise due to silt deposit. Not only would this result in reduction of the water way but also in flattening of the gradient. Both these factors would tend to reduce its carrying capacity. The spreading of the river on the banks and in the countryside would, therefore, be the natural result. The banks and the adjoining areas would consequently come within the sphere of silting. This would, in turn, tend to raise the level of the countryside, which would also restore the original cross-section of the river. A uniform silting of the bed may actually restore its original gradient also. In course of time, therefore, the river will again be confined within its banks. Between the silting of the river bed and the adjoining land, there will always be a time lag. Such a cycle of alternate flooding of the river bed and the surrounding land would tend to keep the river within its course. This would obviously be a stable system and in the process, the land would also be gradually built up. The visitation of floods

at the present moment might actually be coinciding with the flooding period of this cycle.

Now let us see what happens when we try to interfere with Nature's scheme of things. One of the methods generally adopted is the construction of flood embankments or long lengths of revetments along the river banks to prevent flood water getting into the adjoining land. By keeping the river within the confines of artificial embankments, we exclude the countryside from the effect of silting. The entire silting takes place in the river bed. In course of time the river bed rises. It might rise even higher than the surrounding land. With it, rises the flood level higher and higher and the river starts flowing on an artificially created ridge. The original embankments become ineffective and are always in danger of being overtopped by the flood waters of the river. Such a system is bound to be unstable. The embankments might provide temporary relief but the disturbance they cause in the topography of land would be of a permanent and irrepairable nature.

Construction of reservoirs is another method advocated for flood control. Could these reservoirs really solve the flood problem in the North-Eastern India? To some extent yes, i.e. to the extent their capacities would absorb the floods. But here again we would not be tackling the silt. Even the reservoirs in Southern India, where rock formation is of a more solid character, are known to lose their storage to the extent of 15 to 25 per cent in the course of 30 to 40 years by silting. Silting in the north would be on a much greater scale. This silt will continue to come down the valleys. First it will fill up the dead storage of the reservoir. Later on it will come out of the sluice. By the help of silt excluders we will again be throwing back the silt into the river and the main cause of flood will thus remain unremedied. Then the problem will be how many such detention reservoirs we can construct. If the carrying capacity of the rivers is allowed to diminish indefinitely, even big reservoirs will not be able to absorb the floods thereby necessitating the construction of innumerable reservoirs before there could be any effective flood control.

The plan visualized is whether we can canalize silt and bring it on land which would help to build it up; whether we can manage to throw clearer water down the rivers, i.e. the silt coming into the river should be in such a proportion as not to affect its carrying capacity. To put it more clearly, could it not be possible to allow both the river bed and the land to be built up simultaneously without their relative levels changing — as nature originally planned it to be? It is only by such a method that we can have any stable river system.

A study of the behaviour of silt laden rivers has already evoked considerable interest in the recent past. Specially in the case of Assam rivers, the action of silt is more magnified than elsewhere. They exhibit both the destructive and building character of silt. The 'Beels' and 'Haors' of the Cachar district represent typical topographical conditions induced by the silt load of these rivers. In the gradual process of land formation peculiar to such regions, the banks go on rising higher than the land farther away. If there be no suitable drainage, these pockets of depression on either side of the river, which sometimes extend to several square miles, become swampy or permanently water-logged or sometimes turn into huge lakes and the land is rendered unfit for cultivation. When there is a natural outfall, the river, in spate, spills through it and it becomes impossible to dewater the land even after cessation of floods. The small depressions are known as 'Beels' and a big 'Beel' or several 'Beels' constitute a 'Haor'.

Most of these rivers in the Assam valley have carved out a meandering course for themselves. If a loop is short-circuited by cutting an artificial channel, the river carves out a loop elsewhere — thus exhibiting the peculiar characteristic of a silt-laden river which must retain its stable length.

In the Darrang district a railway embankment constructed some 15 years back has obstructed the flow of the Golandi river due to inadequate waterway in the railway bridge. On the down-stream side of the railway line the river follows a fixed and a definite course. But, on the up-stream side the river keeps wandering about within a mile or two of its original course, and has been threatening the existence of several villages. The velocity of the river up-stream is arrested and it deposits the sand it carries in suspension. The bed gets choked up and the river carves out another course.

The inevitable result is the wandering of the river.

The technique of harnessing silt and canalizing it is not yet fully developed. Traces of such works could be visible in the 'Beels' and 'Haors' of Assam referred to above. The methods employed for silting the land are quite interesting. Sometimes 'blind dams' are constructed at the mouth of the streams at their junction with a big river. The low-lying area is thus temporarily converted into a reservoir and the silt coming with the water from the surrounding catchment is trapped into the 'Beel'. An outlet is provided to drain out the water gradually into the main river when the water level in the latter goes down. Another method is the construction of silting channels. A silt channel takes off from a silt carrying river and connects it to a low-lying area where it deposits the silt. It is designed as a 'scouring' and 'non-silting channel' so that it does not deposit its load in the way.

The method adopted in Assam could possibly be employed with certain modifications to train the silt coming down the tributaries of the Ganges. A flood canal suitably aligned along a ridge could take off from the head reach of these rivers. In our northern canal system, the practice, so far, has been to exclude the silt as far as possible by the help of the gigantic silt excluders (the silt excluder at the Nangal Headworks is a typical construction) and allow only free water to enter into the canal system leaving the silt to be washed down the river. In the plan that is now visualized, the process will have to be reversed. The distribution of silt in the river and the flood channels will have to be suitably proportioned so that the whole land including the valley and the river bed rises uniformly without upsetting the drainage system. The silt coming into the land through the flood channels could be trapped by filter dams — on the lines of head — water dams sometimes constructed in the catchment or the foreshore of reservoirs to prevent their silting. After water has deposited its load of silt on land, it could be drained back into the river from which it was picked up. Much clearer water would thus go down these rivers.

The Rapti river-bed in the eastern U.P. has probably risen higher than the ground level of the Gorakhpur district which is protected from the floods by an embankment. Fantastic though it may sound, a programmed flooding from year to year of the Gorakhpur district from the Rapti waters in a controlled manner might help to restore the original drainage conditions.

A year or two ago, there came a brilliant suggestion from some quarter to dredge and deepen the course of the Kosi river to solve its flood problem. This also implied deepening the course of the Ganges from the point of outfall onwards. The suggestion may not have been received too enthusiastically, but this also would be an effort in the right direction. The silt removed could be used to raise the low-lying areas. When, however, one comes to think of the costs involved in dredging a whole river system and transporting the excavated silt to long distances, the solution does not, in the first instance, strike as too encouraging.

Each valley proposed to be built up in this manner would require a proper hydrological survey. The bed level of the river close to a road or railway bridge will give some indications of the silt load brought and deposited from time to time. Detailed surveys of these valleys might reveal that in some cases the course of a whole river may have to be changed before its proper drainage could be restored. A study of the soil as also the cropping practice in the valley will be necessary. Systematic flooding every year must necessitate a change in the cropping programme.

To train up the valley in this manner will be undoubtedly a colossal task. Years ago, the past generation succeeded in diverting the course of a river across a high mountain range. The Periyar instead of flowing into the Arabian sea, now sends its water through a tunnel into the Vaigai valley and thence into the Bay of Bengal. The Cauvery and the Coleroon became alternately flood carrier and carrier of irrigation water as it suited the convenience of the peasants of the Cauvery delta. Some of the big irrigation undertakings are gradually taking shape and these show the tremendous potentialities of human skill and ingenuity. Must it really be very difficult to tame the silt coming from the Himalayan rivers? It should not sound too optimistic if we answer an emphatic "No" to this query.

We are constructing dams and reservoirs one after the other. Years after if we were

to look back in retrospect, we would discover that at every stage we have been only choking Nature's drainage system by drawing the clear water on land and allowing the muddy water to go down the river. Though not exactly in this manner, the drainage-cum-irrigation channels of Western Jamuna Canal System have also upset the drainage of several districts of the Ambala division. Every year we find large areas continuously submerged under water to the great detriment of the standing paddy crops.

Surprising though it may appear, yet how different are our problems in the north and the south. The flattening of slopes in the northern India is causing all this trouble of water-logging and flooding and the remedy would be in steepening these slopes. In South and Central India, the steep slopes only are responsible for soil erosion and wastage of huge quantities of water which escapes into the sea untapped. For conservation of both the soil and the soil moisture in this region, flattening of the slopes is the solution.

Under the force of water, the Himalayas are crumbling as they must. The large scale deforestation in the Himalayan regions both within and outside Indian boarders is accelerating the crumbling process. The crumbled particles, if properly harnessed, will be the wealth of our land, but if allowed or caused to move in a confused manner would mean death and destruction. In this at last how much it resembles "water". We cannot put up a direct fight against Nature. We cannot prevent building of land by the eroded silt. Any attempt to check this process by preventing water to come on land is apt to end in disaster. But we can possibly succeed in regulating this process and our methods must, therefore, be in consonence with Nature's plan and not designed to upset it. It might well be argued that this approach to the flood problem may not bring any immediate relief to the suffering millions. Actual results may be visible only at a later date. This may be true to some extent, but it is sure to make things considerably easier for the generations to come. It would mean living for the future, but will it not be the biggest service one could render to mankind?

D. S. Sinha
Community Projects Officer
(Irrigation)

MODIFICATION OF SOIL TEXTURE*

"The texture of a soil horizon is, perhaps, its most nearly permanent characteristic. Often the texture of the ploughed layer of an arable soil is modified, not by changes within the surface layer, but by the removal of surface horizons, and the development of a new surface soil from a lower natural horizon of different texture, or by the addition of a new surface horizon, say of windblown sand, or of silt loam settling out of muddy irrigation water"†.

It is proposed to describe another way in which the texture of the soil becomes modified. And that is by human agency.

In areas around Isfahan, in central Iran, a very intensive system of agriculture is being practised. The cultivation of vegetables including cucumbers, onions, brinjals (or egg-plants) and tomatoes is especially carried out very intensively. The production of these vegetables involves much human labour. One of the practices which form a part of this system of intensive cultivation is to bring river sand and spread it on the fields. The objective of this paper is to describe this practice, how and why it is done and the economics there of.

The soils around Isfahan are mainly alluvial, clay loams or clays. The seeds of plants, especially cucumbers, onions and brinjals find it difficult to germinate in these soils, and it has been found that unless great care is taken, the germination is delayed by about 10-15 days and the percentage of germination is small. One of the probable reasons for the difficulty of seeds to germinate in the hard soils, is the "crusting" of the soil.

The practice followed, therefore, is to transport a mixture of river sand and gravel to the fields and place it in heaps. In the early spring, ploughing is done, followed by fertilizing with farmyard manure and spreading of compost and village refuse The land is then rolled, the seeds are sown, and then this "modifier" is spread over the soil, about 8-10 cm. thick. Germination

* My thanks are due to my colleague Mr. Thomas H. Day, Soil Scientist with F.A.O. in Iran, for some helpful suggestions. Also thanks are due to Mr. Zarin Gholem who helped me in collecting the data and information for this paper.

† Soil Survey Manual, U.S. Dept. of Agriculture hand book No. 18, (1951), p. 205.

under these conditions is found to be much quicker and better, and, unless extreme conditions of weather are met, this practice is expected to pay for itself.

The quantity of this modifier spread varies with the crop, the cost of transportation and also the nearness to town. However, for cucumbers and brinjals, the amount of modifier is usually about 60 cubic metres per hectar. For onions, the quantity used is about 40 cubic metres per hectar.

The modifier is used only about once in 2-3 years when truck crops are grown. As the practice has been in use for many years the surface texture of soils has been changed considerably from clay to present clay loam, and in some cases gravelly clay or gravelly clayloam. Whether the textural modification would be found necessary any more, after it has been modified for example to a loam, will probably be determined by the economic utility of such a practice.

For determination of the exact advantages of this practice, both qualitatively and quantitatively, much experimental work is necessary. However, the information gathered about the advantages of such a soil practice are:

1. *Earliness of the crop* — In the case of cucumbers, the price difference between the early cucumbers and late cucumbers is enormous. The price for early cucumbers is as much as 10 "rials" per kilo, where for the late ones, it is only about 3 "rials" per kilo. For the Teheran market, Isfahan farmers by the use of the modifier, produce early cucumbers to attract a good price.

2. *The yield of the crop* — The exact increased yield varies, depending on the previous history of the field and also on whether or not, there have been any late frosts in the spring. However, many farmers report that they get increased yield; this increased yield is reported to be as much as 100 per cent or more in years with a heavy late frost, but may be only 10-20 per cent in normal years.

3. Taking the case of a typical jarib (0·1 Hectar = 1,000 square metres) under cucumbers, the economic advantages derived by the use of modifier, are somewhat as follows:

Expenditure	Rials*	Receipts	
1. Modifier 6M3 Rials 75/M3†	450	Minimum yield 200 Kilos. Half the yield considered early and half as normal.	
2. Farmyard Manure	150		
3. Seed	100		
4. Ploughing and other charges including the labour of the farmer	100		
5. Irrigation and other charges	100	100 Kg. × 10 =	1,000
6. Harvesting charges	100	100 × 3 =	300
Rials	1,000	Rials	1,300

* Present rate of exchange is about 80 rials = 1 dollar, and 16 rials = 1 Indian rupee.

† Includes cost of transportation from river to the roadside by truck, from roadside to the field by donkeyback, and cost of spreading it in the field.

This returns 30 per cent profit, which is considered favourable.

If modifier is not used and assuming a normal year, the yield may be 150 to 200 Kg. per Jarib.

Expenditure rials 550

Receipts 150 to 200 × 3 = rials 450 to 600

The net return and the net gain is, therefore, considered much higher when the modifier is used, even in a normal year. In a year with late spring frost, the advantage of this practice is much enhanced.

In the case of onions, the expenditure may be higher as more labour is required for transplanting, care and later harvesting. However, although the expenditure per jarib may be 1,500 rials, the receipts may be as high as 3,000 rials.

The fact that such a practice of textural modification of soils for certain specialized crops is being practised for quite sometime is usually ample testimony of its merit under the condition it is being practised. The extent of these advantages and the detailed reasons for its use can only be found accurately by properly conducted experiments. The addition of sand gravel mixture alone, however, is not considered sufficient, unless heavy doses of farmyard manure, compost, etc., are added and other cultural operations and irrigation practices are properly followed.

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GUHA, D. P., Asst. Research Officer, D.V.C., S.C. Dept., Hazaribagh
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HUKKERI, D. S., Agricultural Officer, Gadag, Dharwar
JAMAKHANOI, M. S., Agricultural Officer, Bagalkot, Bijapore
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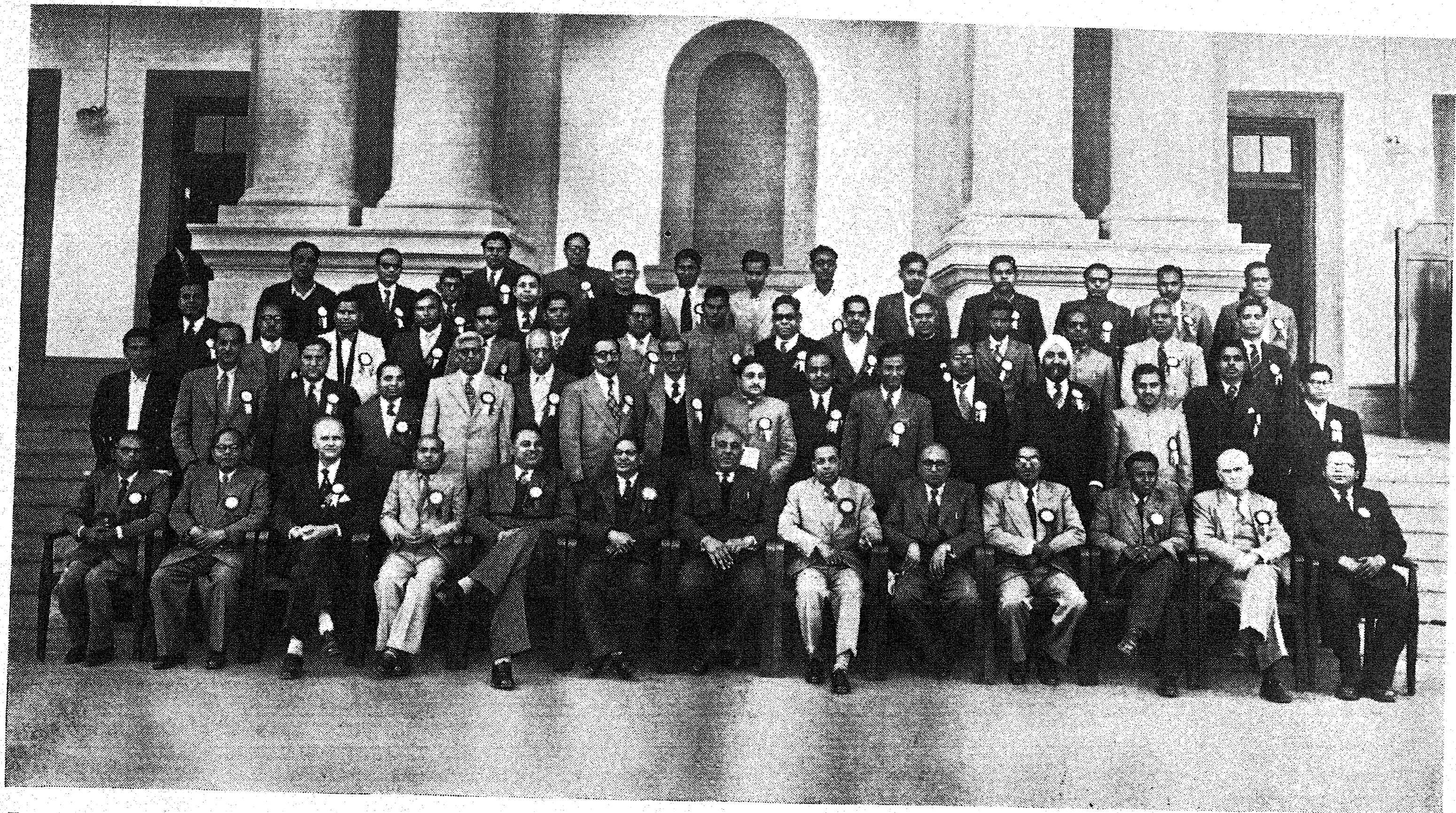

Front row, sitting (*L. to R.*) — P. G. Sinha, S. P. Raychaudhury, R. C. Hay, S. S. Prasad, H. N. Thakur, K. V. Ekambaram, K. S. V. Raman, J. K. Basu, J. S. Patel, A. A. Hakim, S. S. Pillai, W. W. Hull, N. C. Bole.
Second row, standing (*L. to R.*) — S. Pandey, H. N. Mukherjee, S. Mohammad, M. L. Dewan, D. A. Gadkary, M. S. V. Rama Rao, P. S. Lamba, C. P. Bhimaya, H. C. Seth, P. Sen, H. D. Bhowmik, S. R. Rao, B. Singh, J. N. Pandey, U. N. Rai, M. I. Hussain.
Third row, standing (*L. to R.*) — S. Dutt, R. S. Gupta, C. Balan, P. Sinha, L. K. Pandey, S. Pattanaik, S. Mukherjee, S. M. Singh, B. K. Dutt, R. K. Shah, S. P. Sahai, S. Prasad, K. V. Krishnamurthy, N. Hoda, C. Patro.
Fourth row, standing (*L. to R.*) — S. Sitaraman, S. N. Kaul, S. Prasad, S. Ahmad, P. R. Ahuja, B. Nautiyal, A. D. Khan, D. R. Reddy, H. K. Dixit, J. C. Vora, V. S. Subramanian, H. B. Sahay, P. Ghosh, M. P. Sinha, N. Prasad.

Editorial

THE Third Annual Meeting of the Soil Conservation Society of India, held this time in Patna, constitutes a landmark in the Society's history. Members from all over India attended, and in the plenary session where there was a considerable discussion there was a welcome sense of urgency and anxiety to explore how best the lessons of conservation of land and water and the improved use of these natural assets would be carried to the people; and how best action on soil conservation could be initiated as quickly as possible. The recommendations made in each section represent the most urgent problems of the country in regard to that subject. These will, no doubt, be sent to the Governments in the Centre and the States, and the Society hopes that they would receive the attention that they deserve. The need for clarity in drawing up a soil conservation programme as distinguishable from research and extension in the field of agronomy, forestry and major irrigation became clear.

Programmes for the Second Five Year Plan are being drawn up all over India now. Broad distinction, clear enough for administrative purposes, between work that could be included as a soil conservation programme and other work which forms the legitimate charges of different departments and Ministries of Government would seem useful. The suggestions made are tentative and discussions are invited in the pages of this journal.

The study of existing uses of land and water and the mapping of areas under the different forms of land use is obviously the basic step. The importance of having the distribution of the present land uses in the form of maps rather than statistical figures is not widely appreciated. While figures indicate the total amount of change that may be desirable, they are not of any use in programming such change in the different uses of land, e.g. a single or double cropped area, wet or dry land, pastures, forests, waste lands, etc., unless they are marked on maps. The revenue cadastral maps, usually on a 16 in. to a mile scale must remain the basic map for work. It should be possible through the extension agencies of the National Extension Service which are now being introduced all over the country to collect such sample, existing land-use maps showing only the minimum classifications of the type referred to. Reduction of these maps into 4 in. to a mile for working purposes and later perhaps to 1 in. to a mile for record and publication should be possible mechanically through photographic processes without undue cost or delay. While many elaborate and accurate maps through a host of agencies, voluntary and otherwise, have been prepared in

some other countries of the West, it should be possible in rural India to compile such maps of existing land use with sufficient accuracy for working purpose on the lines indicated.

Soil surveys on an extensive scale are not available. The Society at the last annual meeting has stressed its urgency. Reconnaissance soil surveys of grids of 16 miles and 4 miles should perhaps be possible where no work has been done. These surveys have all the limitation of such thinly spread out samples but have considerable use where no maps exist at all, and particularly where soil types do not vary violently. A survey of this kind which could be of use for recommending broad changes in land use should be a part of work that should be undertaken as a soil conservation measure.

Many Governments will, no doubt, be going in for increased afforestation to bring the total area under forests nearer the optimum prescribed by the policy resolution on forestry by the Government of India. The gaps to be filled are very large in many States quite apart from the quality and methods of management of many areas which are now classified as forests and their erratic distribution in relation to the population. Plantation of forests can be for commercial timber, fuel, rural house-building material and fodder supplies for nearby areas or as protection forests in catchments of river valley projects. The last category would definitely come under soil conservation. The increase of forests for rural house-building timber and fuel purposes in rural areas where such supplies are low and consequently farmyard manure is diverted for fuel is quite obvious. Difficulties exist in procuring enough wastelands in areas of intensive cultivation and high density of human and cattle population. Notwithstanding the difficulties, it should be possible, as an organic part of National Extension Service, to draw up a plan of afforestation by stages for each N.E.S. Block year by year for the purpose of ultimately providing the fuel and fodder so as to restore the imbalance in land use in many such blocks. Such afforestation can well serve, if planted out in the right manner, as shelter belts for crops and villages and the benefits of such shelter belts brought home to the villagers. Such schemes drawn up to restore a better land-use pattern for administrative units in this country would form a vital part of the soil conservation programme in this country.

Many irrigation projects are being planned. As has been stated on previous occasions, planned irrigation besides giving the obvious advantages of a storage for the runoff in a catchment ensures very considerable safeguard against loss or misuse of soil through its distributaries and its drainage system. A double crop in place of a single crop or the guaranteed moisture which renders a higher state of fertility or more intensive cultivation practices economically contribute much to the safe return from the soil. In the United States, the distinction has been drawn that storage reservoirs of less than 100,000 acre/feet could be treated as coming under the soil conservation part of agriculture and the larger ones as pure irrigation schemes. Some similar standard if followed up by the allotment of the protection afforestation programme in the catchments of such projects and soil and water conservation practices by biological and mechanical means in the areas including preferential rates for water or land rent for those who consolidate their holdings,

green manure their plots or reserve a small area for fodder production would constitute a most useful step in integrated soil conservation.

The importance of pre-irrigation surveys has been brought home by severe economic losses in some canal systems of India and Pakistan. Yet standard pre-irrigation soil survey (discussed in many previous issues of the Journal) has to be evolved and it would constitute a useful step if pre-irrigation surveys of at least these headwater storage schemes are taken up on a systematic basis and as a part of the scheme as a whole.

Anti-erosion practices are beginning to be better known, thanks to the spectacular soil losses by erosion in many parts of the country. The mechanical and biological methods of control are also getting to be talked about. Ultimately these practices will have to be adopted by the owners of lands themselves, as it is not a practical proposition for the State to produce the finances for the entire work over all areas susceptible to erosion. The best way of extension would be through demonstration. A soil conservation scheme over a typical area, for each N.E.S. Block could be drawn up to be varied according to local needs and all the processes locally applicable demonstrated in that area through a scheme at Government cost but with wholly or partially free labour contributed by the villagers. This would perhaps be the quickest method of reaching the benefits of soil conservation to the people.

While Regional Research Institutes are being set up by the Central Government for studying the extent of erosion and methods of its prevention over large areas, unfortunately adequate data of rainfall and runoff of silt and water do not exist. The importance of intensity of rainfall rather than the total rainfall and its relation to the percentage of runoff of water and silt has still to be grasped by many people. A systematic review of rainfall recording stations with a programme of substitution of automatic rain-gauges that can record intensities as well as total rainfall over a period of fortnight or a month at a time so that several of them could be managed by one technician going round is badly needed. River gauging stations with facilities to measure silt are also few. Automatic record instruments for these would also be economical in the long run. The importance of such measurements, and their direct bearing on the welfare of agricultural problems of the area could, if properly explained, would secure in due course efficient honorary observers.

This disjointed list is by no means comprehensive but would seem to be a suitable basis for thinking and drawing up a comprehensive soil conservation programme for the Second Five Year Plan. Discussion in the pages of this Journal from interested members may be of great benefit.

Welcome Address at the Third Annual Session of the Society on 26 December 1954

—by K. B. SAHAY

ON behalf of the Government of Bihar, I consider it a great pleasure and privilege to extend to you,— Members and Delegates to this session of the Soil Conservation Society of India — a most cordial welcome. The State of Bihar is very ancient in its educational, cultural and political attainments. Patna, the ancient city of Patliputra was the earliest historic metropolis of the first great Indian Empire— the Capital of the Nandas, of Chandragupta and of the Great Emperor, Asoka. It was in this ancient land, at Bodh Gaya, that Siddhartha attained supreme enlightment and became Budha. The famous ancient university of Nalanda, the great centre of culture and learning is 60 miles from here. Numerous conferences of learned men gathered from all parts of India were held in this land from the times immemorial. The present session of the Soil Conservation Society of India can be said to be carrying on the traditions of these learned conferences, and I have no doubt your discussions will be of immense value to us in our efforts to improve the standard of living of rural people by their adopting better land use and management practices for sustained production.

In an agricultural country like ours, the problem of Soil Conservation assumes vital importance. Every man, woman and child must learn that land is our most important natural resource. It has taken Nature centuries to produce an inch of top soil — the top soil from which comes our life-giving food. As a result of misuse of land, one heavy shower after another takes down the river this top soil and the food for years to come. This has become a common story everywhere. In Bihar, in the Chotanagpur region, the ruthless destruction of forests, constant cutting down of saplings, up and down ploughing along the slope, and unrestricted grazing have played havoc with the land. The soil erosion here, as elsewhere, is a man-made problem. For immediate gains — of a temporary nature — man makes his future generation to suffer. The result is hardly any top soil is left on the uplands. The productivity of the land is diminishing from year to year, and the agricultural land is rapidly encroached by gaping gullies. The rain-water getting no chance to be absorbed in the soil, rushes down, laden with silt and causes havoc by flooding the fertile fields of the plains below. The upper catchment is ruined and now sorrow and suffering comes to the plains.

The wanton destruction of forests in the Nepal Himalayas has made river Kosi — instead of life giving — a river of sorrow and suffering for North Bihar.

The costly flood control measures like construction of dams, reservoirs and embankments cannot be of everlasting nature unless the equilibrium of nature — which was destroyed by man — is restored in the upper reaches of the catchment. The afforestation, too, is a long and costly process, and benefits cannot be felt in the present generation.

The soil conservation practices and measures such as contour ploughing, contour bunding or terracing, strip cropping, rotations, manuring and fertilizing, construction of check dams and gully plugs, etc., cannot be taken up by the Government all over the State. Government can start demonstration centres or pilot-projects and it should be left to the rural people to take up these measures and practices. Government can subsidize such activities to some extent but ultimate initiative and efforts have to come from the people concerned.

The misuse of land is going on through generations. The unscientific management of land and wrong practices (such as up-and-down ploughing along the slope) have become established usages. These die hard and change has to be introduced so that new and better land use practices can be the 'usages' for the farmers. The results obtained by you in the experiment stations and laboratories have to be conveyed to the

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tiller of the soil. The measure of success will not be on the result obtained in the research stations but by the use of this knowledge by the cultivators on their field.

I once again welcome you among our midst and wish your discussions a success, which I hope will be fruitful not only to this State but to the nation.

Inaugural Address at the Third Annual Session of the Society on 26 December 1954

by S. K. SINHA

WHEN I was approached by Mr. Raman to inaugurate the Third Annual Session of the Soil Conservation Society of India, I readily acceded to his request. I did so not only because I wished to associate myself with a function held at the headquarters of this State, but also because I believe that the Society is engaged on promoting study, and working out practical solutions of a problem of tremendous consequence to the people of India. The problem of soil conservation is indeed one of vital importance not only to the present generation, but also — and I think to an even greater extent — to generations unborn. It is, in fact, one of the gravest problems facing the human race itself. We are constantly being reminded of the political and economic crisis through which humanity is passing, and of the ominous potentialities of atomic and hydrogen bombs. But there is another crisis, and a deeper one, through which the human race is passing, and this is the demographic and ecological crisis — the crisis created by a rising population and diminishing natural resources. In a certain measure, this crisis is at the root of the political and economic crisis to which I have referred; and yet we hear so little about this deeper biological crisis. I believe that if your Society succeeds only in bringing home to the people of India the nature and magnitude of this crisis, and its grim possibilities — if it is not tackled with intelligence and resolution — the Society will have amply justified itself.

We often talk of poverty in the midst of plenty suggesting thereby that the earth's resources are almost unlimited, and poverty would be wiped out if those resources were quickly exploited and equitably distributed. But is this really true? It has been estimated that while the world's population is growing at the rate of about fifty-six thousand a day, erosion is daily ruining an equal or perhaps greater number of productive acres; and the earth's surface fit for cultivation is certainly not unlimited. Will it not, therefore, be more correct to say that the earth itself is being impoverished, and that unless this process of impoverishment is halted through human intelligence and ingenuity, a richer and fuller life for mankind would become an idle dream?

Many of you, learned gentlemen, must have read Ward Shepard's book " Food or Famine "; but I cannot resist the temptation of quoting a passage from that thought-provoking book. This is what Shepard says: " Modern man has perfected two devices, either of which is capable of annihilating civilization." One is atomic war, the other is world soil erosion. Of the two, soil erosion is the more insidiously destructive. War disrupts or destroys the social environment, which is the matrix of civilization. Soil erosion destroys the natural environment, which is its foundation. Thus, while war with all the weapons of destruction now evolved may destroy the present civilization, soil erosion, if unchecked, can put an end to the very possibility of a civilization. I have sometimes wondered whether the gap of some centuries between the post-Mahenjodaro civilization in the Rajasthan area and the emergence of a new civilization

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in Magadh, was not due to the lethal power of widespread soil erosion in that area.

The problem of soil conservation is, obviously, one of exceptional importance, and utmost urgency in a predominantly agricultural and over-populated country like ours. With every increase of population in such a country, pressure on land increases; essential forests and pastures are destroyed to satisfy land hunger; and the balance of nature — between plant and animal life — is upset. To meet the immediate need of food, agricultural land is over-exploited, and to satisfy the clamorous demand of the present generation, the interest of future generations is sacrificed. This is what, in fact, has been happening. In the past, nature could restore the balance by its own cruel methods of famine and pestilence; but nature cannot now be allowed to apply those cruel remedies. So soil conservation is a vastly greater and a far more urgent necessity now than it ever was in the past.

But the task is not an easy one, and, in some ways, the very progress that we have made in the political and social spheres has made the task more difficult. Some years ago, we took over the private forests that were being rapidly destroyed, for conservation and development. But in spite of the obviously beneficial nature of this measure, we have had to face not only a constant demand from the common people for the satisfaction of their current needs — we understand this demand and sympathize with it even when we cannot meet it fully — but also a great deal of criticism inspired by political motives. This was not unexpected, and I do not complain of it. I have mentioned this only to illustrate my point that in pursuit of soil conservation measures, which must of necessity often involve some sacrifice today in the interest of the future, we should be prepared to face criticism and difficulties. But we must, of course, go ahead, undeterred.

With growing political and social consciousness there is demand for adequate food, and this has led to a rapid extension of cultivation, and to more intensive agriculture. With modern technology, both extension and intensification of agriculture have become far easier than they were even a few years ago; and I am certainly glad that it is so. But we must proceed with care and forethought lest we should aggravate the problem of soil erosion through extractive agriculture and indiscriminate encroachment on forest and grass lands. We have embarked on vast flood-control projects in North Bihar. These North Bihar floods, as you are aware, are partly the result of deforestation and soil erosion in the Himalayas; and some of the North Bihar rivers, particularly the Kosi, has also been destroying large agricultural areas every year. But, with some exceptions, these floods have also been renovating the heavily-worked soil of North Bihar by depositing fine silt. There is no doubt that these floods must be controlled; but these projects must be conceived of not only as measures for protection against floods, but also as measures for conservation of soil and water resources. We have had the grim spectacle this year of crops being damaged in North Bihar both by floods and drought; and we are happy to have an assurance from our engineers that the schemes worked out by them would provide for the utilization of the waters that have been going waste, as well as for the control of floods, and that the process of the periodic rejuvination of the North Bihar soil would not be interrupted.

Gentlemen, I am sorry, I have spoken rather more about some of the problems connected with soil erosion in this State than I had intended to; but you will perhaps agree that it is natural that I should draw upon my knowledge of this State for illustration, even though the points I place before you are of general interest. The problem of soil conservation is one which calls for a concerted application of scientific knowledge in different fields — agriculture, forestry, hydraulic engineering, and so on. It requires the co-operation of public men, social scientists, soil chemists, engineers, and administrators; and your Society is, I believe, the only organization. In this country which has brought together all these diverse elements to study and deliberate upon a problem which, as I have said earlier, is one of vital importance to the future of the people of this country. It gives me very great pleasure indeed to see you all here gathered together to give voluntarily your time and energy to a cause which by a free choice you have made your own. It is a very worthy cause. I trust that your Society will work out, and place the country a planned and co-ordinated programme of

soil conservation, and of reclamation of vast areas that have been damaged by deforestation, haphazard extension of cropping to hill-sides, excessive rainfall, lack of moisture, overgrazing and so on. And I hope you will place your programme before the country in a form that would be intelligible to the common people, and that, in the years to come, your Society would become a regular channel of communication of advanced scientific knowledge on the subject of soil conservation to the people in easy and simple language.

I shall watch your deliberations with keen interest. You have my best wishes, and you can always count upon every co-operation and assistance from the Bihar Government. With these few observations, I have very great pleasure in inaugurating this Third Annual Session of the Soil Conservation Society of India.

Presidential Address at the Third Annual Session of the Society on 26 December 1954

—by H. M. PATEL

I CONSIDER it a great honour that I have been asked to preside over the Annual Meeting of this Society. The Soil Conservation Society of India is as yet very young, but it has already done remarkable work. Its main task is to make both the people and the governments of India and of the States conscious of the urgent need for action to prevent further soil erosion and to secure the proper use of land and water for the maximum benefit of the people of the country. Its principal task is, thus, educative in character, and nothing is more difficult and more heart-breaking than getting people to see clearly that which is obvious to oneself. In other words, this Society needs enthusiasts today and I can only imagine that I have been called upon to take the chair today because I am an enthusiastic adherent of the cause of soil conservation almost as keen as the founder of the Society Mr. Raman.

Of all the gifts of nature, none is more indispensable to man than soil. This complex mixture of animal, vegetable and mineral matters is one of the four principal requirements of life, and with sunlight, air and water it nourishes all plant life and supports human life and most animal life. And yet we have been doing our best over the years to impoverish, if not to distroy, this precious indispensable gift. Our farmers have been ploughing up hill-sides up and down the slope; what few pastures we have have been overstocked with great herds of cattle; fields have been planted with the same crops year after year without any replenishment of the essential plant nutriments; vast acres have been exposed to the sweep of the wind. And the result we can see, if we want to, when we look at the muddied-brown waters of our rivers during the monsoon transporting incredible masses of soil to the sea. During the last 12 months or so, I have had the occasion to visit various parts of this country and to see large areas which have been thus ruined by erosion. And nowhere in these areas did I see any consciousness of the damage that had already occurred and the risks they were incurring in following their age-old methods of cultivation and use of land. The Chambal ravines have already made uncultivable over a third of the area which is planned to be commanded by the canals to be constructed as part of the Chambal River Project. Likewise, over a couple of lakhs of acres are covered by even deeper ravines or *Kotars* along the Mahisagar in the Bombay State. In the Sivaliks, again, vast tracts, which were once rich and fertile, are now lying bare and uncultivable. And, speaking in Patnā, I need scarcely refer to the havoc that can be caused by rivers in flood once

SRI H. M. PATEL, I.C.S., is the Secretary, Ministry of Finance, Government of India (lately Secretary, Ministry of Food & Agriculture, Government of India).

we have allowed erosion to progress unchecked in their catchment areas.

It has been said that the removal of a cubic yard of soil each week from an acre of land, if continued for 30 years, that is one generation, would mean loss of 11 inches of soil of the entire surface. In several parts of this country this is about the total amount of surface soil suitable for cultivation and when that is lost the land ceases to be cultivable. In areas where the rainfall is heavy — and there are many parts of this country in which the rainfall exceeds 30 inches in a year — very heavy loss of soil occurs except where care is taken to prevent a rapid runoff and to conserve water in the land. Quite recently, I had an opportunity to see a film which has been brought to this country by the T.C.M. which showed how much soil is displaced by even one drop of rain. That film dealt with conditions in the U.S.A. There can be very little doubt that a raindrop during the monsoon in this country causes far greater loss of soil, so intense and heavy is the downpour. We can consider ourselves fortunate that we are still left with as much surface soil in most parts of this country as there in fact still is. But we cannot afford to allow that process to continue unchecked much longer.

Our objective must surely be to keep our agricultural land permanently productive, for we have barely enough cultivable land left now to support our present population, and perhaps a little more. It is imperative, therefore, for us to ensure that there is no further inroad made by erosion and that whatever land we have is kept not merely productive, but capable of yielding increasing quantities of agricultural produce. A sound conservation programme, conservation of water and of soil, is what we need, is indeed essential. Such a programme, moreover, must be given the highest priority, for we have to extract from our land ever increasing outputs. Our numbers are steadily increasing, and we have hitherto not taken any really effective or strenuous measures for controlling either human population or cattle population. Today the two are virtually competing with each other. There is not enough land to meet the food requirements of both. The result inevitably is that the latter, the cattle, have necessarily to go short which is one of the principal causes of the poor quality of our cattle. That we can breed magnificent quality of cattle is obvious to anyone who has seen the several well-known breeds of cattle that have been developed in this country. But it is equally obvious to anyone who has moved about in our country-side that a vast percentage of our cattle is so poor in quality as to be worthy of only one description, "useless". Their owners cannot afford to feed them and they are therefore let loose on the country-side to obtain their sustenance where they can. The result is over-grazing which, in its turn, has disastrous consequences from the point of view of the erosion of soil. There can be no two opinions about the urgency of the problem of soil conservation.

The Government of India has also recognized the importance and the urgency of this problem. It has set up a Soil Conservation Board and at its instance most of the States have also established similar organizations. The Central Board, to judge by what it has so far done, appears clearly to be determined to make up for its late start. Seven research, training and demonstration centres are being or have been set up in different parts of this country, each designed to tackle a typical soil conservation problem. Thus there is to be a centre to deal with the laterite soils in Hyderabad, another to study the problems relating to the black cotton soils of Bellary, a third to solve the problem of the ravine lands of the Chambal, a fourth to study the problems of erosion arising in the Sewaliks, yet another to tackle the problem of catchment areas at Hazaribagh and finally for the desert afforestation in Jodhpur. In addition the Board has by grants and loans begun to energize the Soil Conservation Organizations of the States. For the next year it is hoped that a largish provision will be made for soil conservation work. What is even more important is the fact that the thinking at the Centre for the Second Five Year Plan is all in the direction of shifting the emphasis from "Grow More Food" to efficient land use — and that is only another way of saying the emphasis will be on the adoption of sound soil conservation practices.

Soil erosion is unquestionably the most serious disease of our land. We have neglected it too long; fortunately, for us the disease has not become incurable but we must now act rapidly and with determination. The

disease must be attacked from several directions. We must in the first place do intensive propaganda to make people realize whatever we know about soil erosion and soil and water conservation. We know a great deal already but that knowledge is not being transmitted by us in terms which would enable the average cultivator as also the average citizen to put this knowledge to effective use in practice. We must make people more conscious of soil erosion. If we succeed in doing that we shall have taken perhaps the most important step towards slowing down materially the rate of erosion. The method of achieving this object is to secure the maximum co-operation of individual farmers. In the village level workers we have ready at hand a large staff to whom this task of publicity and education can be assigned. The village level worker must be taught to recognize the tremendous losses of soil and water which occur under poor land management and he must likewise be given a good working knowledge of methods of controlling the erosion, of the proper use of land or to use the American expression some idea of land adaptability.

There have to be schemes not merely for the conservation of the soil but also for the conservation of water. Quite a large area is already enjoying the benefit of assured water supply through irrigation, and a large number of new irrigation projects have been undertaken and are on their way to be completed. Along with these indeed preceding their completion — we must take effective steps to spread the knowledge in the areas concerned of how best to use the irrigation water so that not a drop is wasted and no harm is done by excessive irrigation. In other words we must see to it that the irrigation should in no case cause damage by erosion, or through alkali accummulation by water logging. There again there is the need for the adoption, wherever feasible, of the dry farming practices which enable you to kill two birds with one stone: you prevent soil erosion, and retain — in areas of limited or scanty rainfall — all the rain in the fields, thereby making cultivation possible, which otherwise would not be.

We must also simultaneously take up in a planned manner the task of re-afforestation of areas which once had forest cover, but are now denuded. One has only to pay a casual visit to the Siwaliks to see how rapidly the thin layer of soil disappears once the protective cover of forest trees is removed, and the land becomes almost unfit for any purpose whatsoever. The difficulty, the cost and the time it takes to re-establish forest cover should be emphasized, obvious as it is, so that all concerned may appreciate the value of the existing forest cover, and assist in taking proper care of it. It is of vital importance to cherish and to ensure that the protective cover is maintained so as to exercise its maximum beneficial influence.

Finally, a start must be made with the indispensable task of preparing a land capability plan for each field, or group of fields, possibly for each village. Initially, we may attempt such plans on a regional basis, expanding later to district or *tahsil* basis, ending up eventually with a separate plan for each village or groups of fields. This is an enormous but necessary task, if we are really to obtain the maximum output out of each field without causing any harm to the land, indeed while enriching it through proper use.

I have ventured to make these remarks restating elementary but basic facts regarding soil conservation, largely because I have felt that such reiteration can only do good and might by the manner of reiteration even help the expert to appreciate the administrative point of view. Here is a vital field of work. What has to be done, however, can be done efficiently only if there is genuine and enthusiastic co-operation effort on the part of the experts on the one hand, experts in agriculture, in forestry, in agricultural engineering, in soil physics, in agricultural economics, and so on — and the administration, the general body of citizens and the cultivators on the other. In bringing all these together this Society is rendering most signal and invaluable service. I am confident that the co-operation of all these different groups will bear fruit, and to soil conservation will come to be attached as great an importance as shall we say to irrigation and power. I will now conclude with a wish that this Society's deliberations will result in expressing creditable conclusions and even more I say further that they would meet with even greater success in ensuring their implementation later.

Address of Dr. Punjabrao Deshmukh, Minister for Agriculture, Government of India*

BEING closely associated with agriculture my interests in your Society is obvious. Soil conservation is indeed vital for all developments in modern agriculture and forestry, in fact in all types of land uses you can think of for the exploitation of the land resources for the benefit of mankind. It is natural, therefore, that I shall be eager to watch your progress in the fields of soil conservation. I hope you would be able to come to some definite and useful conclusions at the end of your session.

Soil is our greatest asset and we must try to save it. Soil is the life-blood of a nation. We depend on it in every way for our prosperity and for our well-being. Yet we are losing it at a terrific rate from our cultivated fields, from our denuded forests and pasture lands.

In some places we are losing 7 in. of our rich fertile top soil in less than 3 decades while in other places it may be more or less. This soil has taken Nature thousands of years to build. Simultaneously, we are losing enormous quantities of plant food annually which could have supported 2 to 10 crops yielding tons of valuable foodgrains and fodder from every acre of land. Can we afford such colossal loss any longer when our population is increasing by leaps and bounds? Recent sample reconnaissance erosion survey has revealed that in parts of undulating Deccan Plateau about one-third of the cultivated land is now so badly eroded that crop growing is no more a profitable proposition. Yet another survey shows that nearly one-fifth of the land, which was classed as medium soil (9-18 in. depth) seventy-five years ago, can now be classed as shallow soil (0-9 in. depth). Laboratory investigations indicate that the eroded soils are highly depleted of clay and humus. Loss of clay, organic matter and of soil depth severely reduces the field capacity of soils for holding moisture and fertility ingredients. They are ultimately reflected in lower crop yields. Thus, the yields of jowar, as reported in the quinquennial crop report published in 1917, range from 400 to 600 lb. per acre, whereas the present range of yields of the same locality as calculated from crop-cutting experiments stands between 300 and 500 lb. per acre. Similar lowering of productivity of the lands through soil erosion is taking place all over the cropped area of the Union. The problem of soil conservation has, therefore, assumed a vital significance in the arable lands due to their vast extent as also to the colossal damage already done.

A heavy loss of our good fertile soil is also taking place every year in the banks of most rivers and streams and the march of ravines is progressing unabated resulting in utter destruction and desolation of once prosperous villages and productive cultivated lands. No accurate estimate is available today about the extent of damage already done by ravine formation, but the scattered data obtained in some States show the enormity of the situation and the urgent need for an immediate solution of the problem. To quote one instance " In Gwalior State it has been estimated that there are some 800 sq. miles of such devastated land, and, considering the rate of erosion which might have taken place, it was estimated that this devastation has been accomplished during the past 400 years." It is not only a land problem but a social problem as well as these ravines harbour dacoits and bandits who are a constant menace to the villagers. Such problem faces the States of Rajasthan, Madhya Bharat, Vindhya Pradesh, Uttar Pradesh, Saurashtra, Bombay and other States, and unless immediate steps are taken to investigate the problems involved and suggest remedial

*Read by DR. J. K. BASU, Chairman of the Society, at the Third Annual Session of the Society on 26 December 1954

measures, we shall lose more of our fertile lands which will deprive us of our extra food, fodder, timber and fuel.

Our agriculture has expanded from the plains to the hill slopes due to pressure of population. Steep slopes in the foot-hills of the Himalayas from Punjab to Assam, the Nilgiris, the Eastern and Western Ghats, and other hills are being gradually deforested and over-grazed. From the bare and barren hills of the Siwaliks sand has been carried down by sand torrents into the plains below and has buried or destroyed thousands of acres of valuable agricultural land. In Assam hills, large tracts have been laid bare by shifting cultivation. In the Nilgiris, forests on steep slopes have been cut down to make room for potato cultivation and has caused great denudation. In Travancore-Cochin forests on slopes of 40 to 50 per cent have been recently cleared to grow tapioca which has resulted in severe soil erosion and land slides affecting the dams, channels and river beds. The conservation of soils on the hill slopes is, therefore, an urgent matter today. This can be only done by introduction of proper land-use practices.

Then there is the vast desert in the Central India extending from Gulf of Cutch in the west to vast stretches of inhospitable and arid tract known as Rajasthan desert, estimated at about 80,000 sq. miles in extent which must be stabilized. Here due to pressure of ever-increasing population the last vestige of vegetation is fast disappearing creating a condition conducive to further desert formation and destruction. In order to reclaim this vast area we require a sound policy. The existing situation requires, among other things, the extension of the geographic distribution of the best sand-dune loving plants, the breeding of new drought-resistant grasses or plants, development of improved re-seeding techniques, rotational grazing practices and creation of shelter belts. Further, the forestry programme should aim at maintaining and improving agriculture within the desert by:

(1) conserving the soil and moisture relations,

(2) protecting farm crops, gardens, etc., from critical hot winds,

(3) producing wood products, primarily fuel, fence post, and rough lumbers, and

(4) protection of people and live-stock from climatic extremes and living conditions in general.

I have enumerated some of the soil conservation problems facing our country today, but I shall be failing in my duty if I do not touch upon the recent floods which have brought untold miseries to the people of Bihar, Assam, parts of Bengal and Uttar Pradesh. The losses cannot be judged from the financial loss due to destruction of valuable property but from the loss of human lives and its effects on the morale of the people which cannot be evaluated in terms of money. Here soil conservation measures probably can play a very important rôle for the prevention of this destructive menace to human life and property. It is true that as a temporary measure the local flood-control engineering operations of the stream, namely, construction of levees, flood walls, flood ways, equalizing reservoirs and similar devices will be useful but the permanent cure for floods will lie in a comprehensive programme of soil conservation in the entire watersheds of rivers and their tributaries. Soil conservation measures are, therefore, vitally important in all river-valley projects not only for prolonging the life of the reservoirs but also for flood control.

I have mentioned only the broad problems of soil conservation in India which will receive the attention of the Central Soil Conservation Board under my Ministry. But the implication of these problems is vast and varied and require consorted efforts from scientists, technicians, educationists, lawyers, economists and social workers. It will require the co-operation of the public, the farmers and the publicists. As a matter of fact, everybody must be made ' soil-conservation minded ' if we are to achieve any results within a reasonable time. In Nature soil is in equilibrium with its environment and it must be treated according to Nature's own way for its conservation.

Every acre of land must be used according to its need and capability. Misuse of land will bring in its train disaster and miseries untold. This living doctrine must be grasped and preached. Soil conservation is a way of life and it must be taught in schools and colleges. It must be impressed and enforced by demonstration, persuation and legislation. We must provide for the people the

(*Continued on page* 83)

Messages Received for the Third Annual General Meeting of the Society

Mr. Herbert D. Vogel, Chairman of the Board, Tennessee Valley Authority, Knoxville, Tennessee

I would be most pleased if you would convey to the participating delegates my own best wishes, and those of TVA, for a successful meeting.

The peace among nations which all of us earnestly seek will grow stronger as we understand one another better. Understanding grows as men learn to appreciate the problems each of us faces in providing the necessities of life and improving our standards of living.

The agriculture of the United States has been greatly enriched by the exchange of knowledge between my country and yours. I hope that the many scientists and scholars of India who have visited TVA and studied the agriculture of the Tennessee Valley have been able to glean information which has been helpful in meeting the farm problems of India. Assure the Society that our doors are open to them in the future and that we will hope for a continuation of the pleasant and mutually beneficial relations of the past.

Sir Bernard Keen, F.R.S., Retiring Director, East African Agriculture and Forestry Research Organization

I send my greetings to the members of the Soil Conservation Society of India, on the occasion of its Third Annual Meeting, and I wish them every success in their deliberations. Proper measures for the conservation of the soil are of vital importance in tropical conditions, especially where, as in the case in India, the population pressure on the land is high, and still increasing. But, without research, both long-term and immediate, proper measures cannot be developed, and I trust that the Society will impress on those responsible for providing funds, the paramount importance of research. India has many soil scientists who are doing excellent work, and it is a cause of much gratification to me, that a number of them received their post-graduate training under me when I was at Rothamsted. I trust they will continue to add to our knowledge of soil science, and to the practical applications of that knowledge.

Mr. Leonard Elmhirst

Fuel, fodder, firewood and forest represent for me the four major problems that must be met and solved by the conservation enthusiasts in India today before any dam is safe on the capital invested in dams or even in the planning of dams.

I saw good work at Poona on the selection and breeding of grasses and the benefits of controlled grazing. We have doubled the value of our grazing by the use of electric fencing in Britain. One day you, too, will find it cheap.

Best wishes to all my friends and to yourself.

Mr. Doughlas Ensminger

While I am writing, let me also express my disappointment in not being able to attend your Soil Conservation Society Meeting, scheduled for this month. I am leaving for the States today and will not get back until the night of the 29th.

May I express my best of good wishes for your Society meeting. I would like to tell you that as I have travelled up and down the roads of India, I have been increasingly impressed with the great need for a really dynamic nation-wide soil conservation programme where the primary emphasis is with the village and village cultivator. Anything your Society can do to facilitate a national programme in soil conservation that takes roots in the minds of the villager, will be a great contribution to India in its longer-term development.

Mr. M. Leloup, Director, Forestry Dn., F.A.O., Bangkok

My Organization, among other things, attaches great importance to the teaching

of conservation to the general public. Soil conservation in the commonly accepted sense means the wise management and use of renewable natural resources and its primary object is to preserve the productive capacity of these resources. What we are especially concerned with is the education of the population as a whole, and in particular of those laymen who can greatly influence public opinion. Even in countries where bread is plentiful, children are taught not to waste bread: why should it be more difficult to teach them respect for an infinitely more valuable asset — the soil that produces the bread, together with all the other good things indispensable to human life?

I wish you every success in fostering the ideals of soil conservation.

Sri B. Pattabhi Sitaramayya, Governor, Madhya Pradesh

I regret I am unable to be present at the Third Annual General Meeting. Soil erosion is, in fact, the least suspected but most damaging factor in the impairment of cultivation. Nature is sufficiently harsh but man's injudicious conduct adds to nature's impositions on man. The erosion of soil on hills is particularly lamentable and the great factor is the education of the tribes in regard to the danger of their ancient system of cultivation by burning the grass and cultivating the land. Though it may give immediate results to them, subsequent consequences are disastrous to cultivation as well as to the condition of the hills. I hope that the conference will concert measures which will be effective and immediate in their results.

Sri Jairamdas Doulatram, Governor of Assam

When we speak of Soil Conservation, we speak of one of the basic problems of national prosperity. The human factor influences the economic progress of the country. The material factor influences no less. Probably no other item is so vital in this respect than the condition of the soil which gives to man much of what he needs — food, clothing, shelter and a number of other things. Out of the soil, grow most of our raw materials for this purpose and so if we do not take care of our soil, we shall be committing a suicidal mistake. Luckily India's scientific conscience is fully awake to the need of the situation and it is a matter for gratification that our specialists meet so frequently to deal with problems relating to soil conservation. We all stand to gain by their labours. I have no doubt that the present meeting will give us good fruit. My best wishes are with the organizers for the success of the present session of the Soil Conservation Society of India.

Sri C. M. Trivedi, Governor of Andhra

I am very glad to learn that the Third Annual General Meeting of the Soil Conservation Society of India will be held at Patna from the 26th to 28th December, and that it will be inaugurated by Dr. S. K. Sinha, Chief Minister, Bihar State. I send my very best wishes for the success of the conference, and will look forward to reading about its deliberations with great interest. Needless to say, the importance of soil conservation can hardly be over-estimated.

Sri C.P.N. Singh, Governor of Punjab (I)

I am glad to learn from your letter of the 24th November 1954 that the Third Annual General Meeting of the Soil Conservation Society of India is taking place at Patna from the 26th to 28th December 1954.

It is needless for me to emphasize that with the vast programme of agricultural development, which India has undertaken, the allied problems of soil conservation and anti-erosion work have naturally assumed considerable importance. A lot of scientific research is required to solve these and to guide the agriculturists on the correct lines. Unless an all-round progress in scientific research and development in this direction is made, I am afraid agriculture shall not be able to keep pace with the modern needs. A good deal still remains to be done in our country as compared with other advanced countries, and I am confident that our scientists will leave no stone unturned to be on par with them. Our agriculturist is not too conservative but is quite shrewd and understands his interest. If the scientific methods are properly brought to his notice and sufficient facilities are provided to him, he will quickly take to these. No doubt, the villagers themselves have to take steps

as suggested to them by our scientists in the direction of soil conservation. Before, however, they can be expected to do this, it seems a good deal of educative and propaganda work has got to be done.

The very fact that over 70 per cent of India's population is engaged in agriculture clearly indicates the necessity that every citizen whether living in the rural areas or in towns should have an intelligent understanding of these problems and needs and assists in the solution thereof to the benefit of all. It will help to a great extent if the education system in our schools both in rural and urban areas is given an agricultural bias in order to enable our youngmen to evince interest in this direction.

I wish the deliberations of the Society, which is faced with such an important and great task, all success.

Sri R. R. Diwakar, Governor of Bihar

I am glad to learn that the Third Annual Meeting of the Soil Conservation Society of India is going to be held at Patna in the last week of December. The vital importance of soil conservation in the economic life of the people can hardly be over-emphasized. We have seen how valuable lands are constantly turned into waste due to nature's vagaries. This problem needs to be tackled in a sound scientific way in national interest—especially in the context of necessity for more lands for cultivation to meet the needs of our growing population. It is a matter of satisfaction that this forms an important item in the programme of our River Valley Projects. This Society deserves all support and co-operation. I understand a number of eminent scientists, specialists and prominent persons in public life from various States are going to attend the forthcoming session. I extend my heartiest welcome to them and wish their deliberations all success.

Sri P. S. Kumarswamy Raja, Governor of Orissa

I send my best wishes to the Soil Conservation Society of India on the occasion of its Third Annual General Meeting being arranged to be held at Patna from the 26th to the 28th of this month.

The nurturing of the soil is a matter that should receive due attention in a predominantly agricultural country like India, if we are to avoid the major crisis that will overtake us on the economic front in the long run by our continued utilization of the land at the present pace. There has been literally considerable pressure on the soil because of the growth of population and it will be disastrous if we exhaust its life-giving properties prematurely. We cannot be, therefore, too careful and there is need for bestowing some thought on the question of soil conservation.

I am glad that in the Soil Conservation Society of India all those who are interested in conservation work have now a forum for exchanging thoughts on the dangers in the present methods of using the soil and on the need for maintaining a proper perspective. The Association in its Journal publishes valuable information in regard to soil conservation work and I am sure that the ensuing deliberations of this body also will be useful, as representatives from Agriculture, Forestry, Engineering and other relevant Departments of the Union and State Governments, the Planning Commission and the River Valley Project authorities are proposed to be approached to participate in the forthcoming meeting.

We are now engaged in the great task of nation building through our developmental plans, and as a major part of the work in the community projects areas is concerned with securing improvements in land-use and agricultural practices, the Five Year Plan covered proposals for the control of erosion and the conservation of soil and water. Consequently, a Central Soil Conservation Board has been constituted by the Union Government in December 1953 for organizing and co-ordinating research in soil conservation. This Board has since decided on starting regional training, research and demonstration centres to work out the techniques suitable for the local areas and to arrange for their demonstration also. Seventeen States of the Indian Union seem to have set up also State Boards to co-ordinate the soil conservation work of the various Departments at the State level. I also remember the Madras State has passed a Contour Bunding and Contour Trenching Act in 1949. All these show how we have made a beginning of a nation-wide effort to tackle an important problem, whereas only sporadic efforts in one or two States such as terracing work in the Dekhan (Bombay) and afforestation in

Sivalik Hills (Punjab), had been made during a number of years in the past.

Conservation work in the new dispensation of planning and development, however, needs the co-operation of farmers' associations as a good deal of the work has to be done by the farmers themselves. The establishment of such associations has been recommended in the Five Year Plan wherein it is pointed out that considerable success has been achieved in the U.S.A. by organization of farmers into Soil Conservation Districts for carrying out soil conservation programmes. While it may take time to enact the requisite legislation and bring such associations into existence, I think it will be useful if useful popular literature is got up by the Soil Conservation Society of India in the local languages so that new knowledge may be disseminated far and wide for the easy comprehension of the rural population.

Having just referred to a particular experience of the U.S.A. mentioned in the Five Year Plan itself, I may also make a reference to the Americans having realized the need for circumspection in the further excessive exploiting of the nation's soil. Theirs is a comparatively young country and yet, one-third of the top soil there would appear to have been destroyed already. In this connection, I note that Dr. Hugh H. Bennett is cited in an article appearing in the *Harijan* dated March 13, 1954, as deploring the enormous loss of good crop and range land to the extent of several millions of acres in the States' short life, and it is stated in the aforesaid article that this loss cannot be restored. Here, I think, is a warning for us in India. There is really something in the view that the traditional restraints on population growth embodied in our religious practices, as well as the workings of nature, formerly helped in the maintenance of a balance between mankind and other forms of life, that the tremendous increase in the numbers of our urban folk expanding into rural areas is not quite a healthy development, and that we should not restrict the area of cultivation in any way, or allow the soil to be excessively impoverished by drawing too much on its bounty.

May we, therefore, learn to sustain our soil, and preserve its productivity by allowing live bacteria, protozoa, etc., to keep the soil alive! We may take steps for preventing erosion, and also try to check the ravages of wind-action which renders large tracts sandy. We may promote afforestation also and strengthen the resources of soil-binding grass, and adopt measures for resettling the tribals whose practices of shifting cultivation need to be ended, being so destructive of the forests through their denudation. But with all these efforts let us also remember the need stressed by the better minds of the world, to respect the balances needed in life and contemplate on the fact that only the soil-mining power per man has been increased by modern science. With utilizing nature as may be justified we should *pari pasu* think also of measures to check the inordinate population growth so as to lessen the pressure on the soil.

I wish the ensuing Annual Meeting of the Soil Conservation Society of India every success.

H. H. the Rajpramukh, PEPSU

Some people have called soil as the 'Mother Sustainer' of mankind. Perhaps this is the aptest name one could give it. Its importance need, therefore, hardly be emphasized. As a matter of fact, the subject of soil conservation has now become an important topic of the day in order that we can effectively meet the growing demand for food of a rapidly increasing population. The science of agriculture, forestry, and engineering has many wonderful achievements to its credit, and has helped to solve many of the country's most baffling problems. There is plenty of scope for yet more advanced research in every direction, and I am quite sure that our teams of tireless and enthusiastic field workers will continue to devote their whole-hearted attention to it. I wish them all the best of luck.

Sri Yuvaraj Karan Singh, Sardar-i-Riyasat, Jammu & Kashmir

With ever expanding need of increasing food production and bringing the maximum amount of land under cultivation, the necessity for creating a scientific consciousness of soil conservation and allied studies has become imperative. Experience shows that indiscreet cultivation of land and denudation of forests have resulted in great misery in the form of soil erosion, floods and precipitous shortage of rainfall. Your Society will

indeed be doing a signal service to the nation in focussing the attention of all concerned on these problems, so that while on the one hand our national wealth of forests is maintained, on the other a rational approach to our soil conservation problem is made. I send you my good wishes.

Sri Jaya Chamaraja Wadiyar, Maharaja of Mysore

I have great pleasure in sending this message to the Third Annual General Meeting of the Soil Conservation Society of India which is to be held at Patna from the 26th of this month.

Soil conservation is, in the final analysis, nothing less than the conservation of the earth's capacity to sustain life. Its influence on the economic and social stability of a nation is slow to be perceived but quite real and inescapable. In our country vast tracts have been rendered desolate and sterile through unwise exploitation and neglect by man. Any plan to stop this dangerous process and to repair the damage already done to the earth should, therefore, be regarded as an invaluable contribution towards national welfare. The Soil Conservation Society of India endeavours to focus expert attention on this problem in all its aspects and to rehabilitate despoiled land by scientific means. It is very gratifying to see the knowledge and effort which the Society is bringing to bear on this task.

I wish the Soil Conservation Society of India every success in its important work.

Sri Morarji Desai, Chief Minister of Bombay

Soil is the primary basis of life which has been created and preserved by nature for the benefit of the living worlds. Man has exploited nature rather vigorously in the recent past and there is imminent danger to the continuance of this very basis of man's life and happiness. The work of soil conservation has been begun in earnest in some countries and also since recently in India. Your Society can render valuable assistance in this important work by providing a forum for exchange of views and by adding to the scientific knowledge on the subject. I wish success to the Third Annual Conference of your Society in this important task.

मुख्य मंत्री, विन्ध्य प्रदेश

आपने मुझे तृतीय वार्षिक बैठक के लिए निमंत्रण दिया उसके लिए आपको धन्यवाद।

यदि मैं इस बैठक में शामिल हो सकता तो मुझे बड़ी प्रसन्नता होती। आपका कार्य बहुत महत्वपूर्ण है। उससे राष्ट्र को बहुत लाभ होगा।

आपकी इस बैठक के प्रति मेरी पूरी शुभ कामना है।

Sri Mishrilal Gangwal, Chief Minister, Madhya Bharat

I am glad to learn that the Third Annual General Meeting of the Soil Conservation Society of India will be held at Patna in the last week of December. Soil erosion in the past few years has become a serious problem in the country and we in Madhya Bharat are also faced with the same. I am sure the scientists and the soil experts attending the meeting will find out some ways and means for putting an early check on erosion of fertile lands in our country. I wish the conference all success.

Sri R. S. Shukla, Chief Minister, Madhya Pradesh

I am happy that a Soil Conservation Society has been formed in our country. The economy of our nation is based predominantly on land; and much will depend on the manner in which we put this natural resource to its proper uses. So far we have been drawing upon it heavily, and without caring to look after its proper preservation. Floods, soil erosion and faulty agricultural practices have been allowed to cause irreparable damage to land. The problem of soil conservation will become very acute if we fail to deal with it immediately. I am sure that the Soil Conservation Society of India will be able to make its due contribution towards this direction.

Sri Bisnuram Medhi, Chief Minister, Assam

We have, in India, regarded soil as a part of our life. Since ancient times the value of the soil and its contribution towards the growth of civilization has been recognized. Like air and water, soil is necessary for our very existence. We have often been cruel

to good earth and our unintelligent use of it has deprived us from many of its blessings.

The value and importance of soil is all the more for a State like Assam which is visited annually by floods. It is soil which has helped us in building embankments and thereby preventing damage to crops and loss in property of our people.

We have, through reckless denudation of our forest wealth, robbed the soil of its fertility and to that extent made the nation poorer. Different types of soil can be used for different purposes and it is only in the fitness of things that the Soil Conservation Society of India should devise ways and means for protecting the virtues of one of God's choicest blessings on men. I wish the conference all success. *Jai Hind.*

Sri Bhimsen Sachar, Chief Minister, Punjab

Punjab has been perhaps the pioneer State in this country to realize the dangers of erosion particularly in the Siwaliks. The Land Preservation Act was passed in 1900, and large areas have been closed under its provisions. Advantage has also been taken of Section 38 of the Indian Forest Act to undertake afforestation and protection measures in privately owned areas. Soil conservation measures are vital in the multi-river valley projects and to prevent the inroads of the desert sand. One of the greatest needs is to make the population — realize the benefits of soil conservation and dangers of accelerated erosion. Social re-construction programme can be made easier and more effective if adequate soil conservation measures are practised. I am sure that the Soil Conservation Society of India is doing very fruitful work in this direction. The need for research work to enable the proper utilization of land is obvious, and I trust that the Society is alive to the need for such work. I wish the Society every success.

Dr. Y. S. Parmar, Chief Minister, Himachal Pradesh

Soil erosion today is a matter of great threat to the country as a whole and is a problem of great national importance. From every quarter scientists are sounding warnings about the relentless advance of desert-like conditions mostly brought about by man himself. No efforts will be too great in evolving measures which will help to conserve the fertility of the soil and minimize the devastation caused by floods.

On the occasion of this Third Annual General Meeting of the Soil Conservation Society of India, I take this opportunity of wishing the members of the Society God-speed in their deliberations. I sincerely trust that with the exchange of varied experience and expert knowledge, methods would be devised to tackle this vital problem of soil devastation within the economic resources of the country.

Sri K. Hanumanthaiya, Chief Minister, Mysore

I am happy to know that the Soil Conservation Society of India is holding its Third Annual General Meeting at Patna. The majority of our people live in the villages, and they are dependent on land in a very intimate manner. Anything which is done to preserve the land, and improve its fertility, will be the greatest service that could possibly be done. The Soil Conservation Society of India is thus devoted to a task which will be of immense benefit to millions of our countrymen.

I wish the deliberations of the Society all success.

Other Messages

The Chief Minister, Saurashtra, also sent his good wishes for the success of the Society.

Soil Conservation Engineering*

—by K. V. EKAMBARAM

AT the outset, let me thank the Soil Conservation Society of India for inviting me to preside over the " Soil Conservation Engineering " section of their third session. The nation would one day be very grateful to the Soil Conservation Society of India, for focussing the attention of the country to this problem of soil conservation which though very important seems to have been neglected far too long. In the matter of natural wealth, God has endowed on us, I would put soil foremost, water second and then only forest, mineral, etc. The soil is given to every individual as it were, so that he can use it properly and make a living. But it has become so common that a proper use of it has been forgotten. We seem to be like the farmer who killed the goose for its golden egg. For a soil once eroded and wasted can never come back. It is how I would say, soil conservation is more important than water conservation. Nature replenishes the water that is lost, by an annual precipitation. But in the matter of soil, there seems to be no such replenishment. Soil once lost seems to be lost for ever. What one American farmer said to another when a dust storm was blowing over Kansas, " Look, Kansas is flying " is very striking and I can never forget that.

The best way of defence is to attack. So soil conservation is best dealt with by combating soil erosion. Here it is that an engineer also has a part to play.

If you want a good example or rather one of the worst examples of soil erosion and what havoc it can do, you need not go very far. It is at our very door, the case of River Kosi, with which I am at the moment connected.

The River Kosi is at its debouch in the plains, the third biggest river next only to the Indus and Brahmaputra. It drains a catchment basin of some 22,888 sq. miles. The rainfall in the Himalayas catchment increases from about 70 in. at the foot-hills to about 140 in. in the southern slopes of the Great Himalayan range. It is a perennial stream whose three main tributaries, the Sun Kosi from the west, the Arun from the north and the Timur from the east meet at Tribeni to form Sapt Kosi. Below the confluence, the Sapt Kosi flows in a narrow gorge for a length of six miles to its debouch in the plain near Chatra. Afterwards it runs in a sandy alluvial plain, traversing in Nepal Terai and North Bihar exhibiting all the features of a deltaic stream with many bifurcations and interlacings till it falls into the Ganga.

The River Kosi is well known for its vagaries. After its entry into the plains, it has been shifting its course and the records which are available from 1731 show it has been moving to the west. In the last 200 years or so it has shifted about 70 miles. There is an interesting map showing the various courses which the Kosi occupied from 1736 and if averages are worked out showing the approximate rate of movement in miles per year, it even comes to 1·60 miles per year for the period 1922-33. I doubt if there is any similar record anywhere else in the world.

Very interesting accounts can be heard from people who have lived in the Kosi area. I have heard from people that when the river was running easternmost in the area, there was one English trader in Nadpur who had a number of boats. When floods came in a year to a very high level he presented all his boats to the Indian merchants and asked them to make their own arrangements to get out and they all got out and established the present Balua Bazar and the Pratapganj Bazar. The story brings to mind the Noah's Ark of the Bible. At one time the river occupied the bed of the present Susar Nadhi and it seems the O.T.Rly. on this side and the E.B.Rly. on the other side had a steamer ferry across at one place. Now the present Susar Nadhi is a shallow silted up-stream which can be crossed by foot in winter.

The river's movement to the west has also not been gradual always. It is suddenly

* Presidential address delivered at the " Soil Conservation Engineering " Section of the Third Annual General Meeting of the Society held at Patna from 26 to 28 December 1954.

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known to have changed its course several times. When the river was east of Bhimnagar, I heard, a railway line was laid from Pratapganj to Bhimnagar but only one train ran over that line because the river destroyed the line in a sudden westerly movement. It seems the train could be taken back only after one year.

Such are the vagaries of the River Kosi. It has engulfed many villages in its movement. Their boundaries can be seen only on maps and their inhabitants have settled elsewhere and recount tales of their boyhood. One gentleman told me he had shifted his place of residence five times. At present it threatens to engulf the town of Nirmali and when one goes there one gets the feeling as though a dragon is keeping his mouth wide open, ready to swallow.

So what is all this due to? The tributaries of the river as they travel through the Himalayas collect a lot of silt and the river as it enters the plains carries a heavy silt load. Silt sampling has been going on in the river since May 1947. This has shown the percentage of total average suspended silt load to the total average runoff by volume is ·2 per cent. In total quantity, the average annual suspended silt load is 94,142 acre/feet. Out of this, coarse silt is 10,655 acre/feet or 11·32 per cent.

The river has a fall of ten feet per mile above Chatra gorge. After it enters the plains the slope varies from 5 ft. per mile to ·25 ft. per mile. The coarse silt that the river carries gets deposited as the river gradient becomes flatter and flatter. Observations show that bulk of this deposit takes place between Hanumannagar and Karhera. The result of this deposit seems to be that the river obstructs its own bed and hence the river tends to shift and a new channel is formed. Thus the translation of the river is ascribed to the heavy deposit of coarse silt it carries.

This coarse silt is all as a result of the soil erosion that is continuously taking place in the Himalayas. Though I have just visited only the foot-hills, yet I saw a good portion on the steep slope being cleared for cultivation and cultivation going on too. There are some other places where the slope is so steep that land slides are possible and are taking place. I happened to see a small length of one of the streams that join Kosi, namely the Kokakola. The bed and sides of this are very steep. The sides are full of gullies and so during rains it brings down a lot of detritus.

So it looks ultimately that by soil conservation alone the matter can be remedied. In a stream like the Kokakola there is scope for doing a good lot of work. Check-dams can be constructed across the gullies and at a suitable site across the main stream, a dam can be put up too. Thus, considerable silt can be held up besides floods being moderated. If treatment could be given to every small stream that joins the Kosi, this will go a long way in improving the situation. Already efforts are being made to work in this direction. I have talked of only the engineering side. There is no doubt considerable work for the forester and agriculturist too.

The work under the present Kosi Project, if I may say so, is a big work under Soil Conservation Engineering. The barrage, that is proposed between Bharda and Bhimnagar is a big check-dam across a mighty river, intended to flatter gradient in the upper reach and prevent the coarse silt from rolling down. Besides embankments, a number of spars and groynes will have to be put up for preventing the river from attacking the banks.

The canal system is expected to bring back the land which has been ruined by sand deposits, to life.

We propose reclaiming a devastated area of about 10,000 acres near Bhimnagar by building a detention reservoir, in which silt will be trapped and deposited.

But above all this, the works that will have to be done in the Himalayas will call for the best efforts from the engineer. At first, there are no proper communications. These will have to be formed. Works proposed will have to be intelligently designed with local materials. The river behaviour will have to be carefully watched and suitable spars and groynes will have to be put up to prevent the river from cutting its banks.

That day when we can turn this Bihar's River of Sorrow, into one of use for man and put her in harness as it were, that day will be a day of triumph in Soil Conservation Engineering.

Forestry in Soil Conservation*

—by C. R. RANGANATHAN

I AM grateful to the organizers of this meeting of the Soil Conservation Society of India for doing me the honour of asking me to deliver the presidential address of the section on Forestry in Soil Conservation.

India enjoys what is often described as a "forest climate", except for certain arid regions in Rajasthan and on the higher Himalayas above the tree line. That is to say, the vegetational response to the factors of the locality is a form of forest. In the moister regions, the forest forms an integral canopy at some elevation above the ground. As the rainfall increases, several subordinate layers or storeys of vegetation appear under the top canopy formed by the tallest trees. In the wet evergreen forest we have the picture of an almost solid mass of vegetation, arranged in many tiers. Where the rainfall is less than 40 in., the forest tends to become open, the trees are shorter and a definite canopy may not be present. As the conditions become drier, the forest degenerates into scrub consisting in extreme cases of widely spaced groups of usually thorny bushes. It is probable that even in scrub forests, where utilization of light and above ground space seems partial, the occupation of the soil by the root systems of the trees is complete.

The efficiency of the forest as a hydrological agent, as compared with other forms of vegetation such as grasses and crops or even with bare land, has often been called in question. But there has never been any doubt about its complete efficiency as a soil conservation agent. From the point of view of its physical and protective effects, the forest functions at three levels, namely the canopy level, the ground level and the level reached by the rootlets underground. The protective influence of the forest on the soil is thus more comprehensive than that of alternative forms of vegetation, inasmuch as the forest extends vertically over a greater distance both in the air and in the ground and interposes a screen between the soil and atmospheric factors, thereby creating a moderated micro-climate within its boundaries.

It is axiomatic that no soil erosion, other than geological erosion, can occur where the forest is left undisturbed or where it is managed under carefully controlled conditions. I have, however, seen forests, whose outward physiognomy appeared good, but which on being entered and inspected showed a complete absence of ground vegetation due to overgrazing, which had resulted in gully formation. A badly managed forest may thus give a false sense of security.

I was asked a thought provoking question yesterday on the subject of soil erosion. "India" my questioner said, "is an old country where agriculture has been practised, more or less in its present form, for several thousand years. Our agricultural yields may not be spectacular, but at least our soils have been continuously productive through the centuries. What has gone wrong during the last few years to give rise to all this fuss about soil erosion and soil conservation and to gloomy prophecies of disaster?" I think there is considerable point in this queston. Soil erosion, as a widespread evil, is of comparatively recent origin. It probably started about a 100 years ago, as one of the unhappy consequences of the land policy of the British administration, under which extensive areas of wood-land were cleared, cultivated and quite frequently subsequently abandoned by the people after the beginning of erosion had set in. Chaotic conditions prevailed till active reservation of forest lands was taken up in the last quarter of the last century and the first forest policy for India was declared in 1894. Failure to take over and reserve specially vulnerable areas, for example, the Hoshiarpur Siwaliks, has led to serious erosion in these regions. During the last war, the "Grow More Food" campaign was responsible for the initiation of erosion in many places. Under

* Presidential address delivered at the "Forestry in Soil Conservation" Section of the Third Annual General Meeting of the Society held at Patna from 26 to 28 December 1954.

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the drive for increased food production, woodlands and marginal lands were stripped of their cover, cultivated for a short term and abandoned. This campaign was responsible for the intensive cultivation of potatoes on steep slopes on the Nilgiris, without any protective devices. A great many private Eucalyptus plantations were cleared to make room for the potato cultivation. Soil erosion has, in consequence, become a serious menace on the Nilgiris. Other similar examples can be multiplied.

Soil erosion has been a locally acute problem in many places for many decades, but it has assumed the dimensions of a national danger since the last war. The broad general reason is, I think, that the mounting demands for more and more land to cultivate, have led people to break up land on slopes and vulnerable sites which cannot be cultivated without causing erosion, unless special conservation techniques are employed. All the good safe agricultural lands have long been under cultivation. The new lands recently brought under the plough are in many cases eroding rapidly.

It is one thing to say that forests ensure complete soil conservation and quite another thing to bring forestry to the aid of village communities to prevent and control soil erosion. The forest officer who is used to operating in a domain dedicated to forestry under the protection of a special law, with a special police establishment, under orthodox principles of sustained yield mangagement, finds it exceedingly difficult to adjust himself to the conditions in which village forestry has to be practised. Yet the job has to be done, not only in the interests of the rural communities but in those of the forest department itself, because the departmental forests cannot, in our present conditions, survive long without the goodwill of the people.

In considering the role which forestry can play in soil conservation, it would be wise to accept the liberal interpretation of soil conservation as soil improvement, as Dr. Parker recommended yesterday. One obvious step towards soil improvement and building up of soil fertility is to enable cowdung to be used as manure, instead of being burnt as fuel, by raising village plantations to supply firewood besides small timber for agricultural and domestic requirements. In many cases, villages lie at the foot of or in close proximity to low hills or hillocks, which have been stripped of every vestige of vegetation and of most of the top soil through uncontrolled grazing and browsing. In the " birs " of Rajasthan similar causes have led to the complete disappearance of all good grasses and fodder yielding trees and left a relict vegetation of Salvadora and Capparis trees which are useless. It should be the task of forest officer to rehabilitate these degraded areas by the planting of trees of fuel and fodder value. The task, I know, is all but impossible in the existing soil and biotic conditions. But it can be tackled successfully, given faith, energy and funds, by the use of fencing, selected species and even fertilizer if necessary.

In the Gangetic basin, the land is in places so valuable for agriculture that space is grudged for even an occasional patch of trees. Yet, it is vitally necessary that tree growth should be encouraged here and there in these tracts, not only for the direct advantage of increasing wood supply, but for protective purposes and for providing harbourage for bird life. The only possible solution is to encourage farmers to put down occasional trees, preferably leguminious, with deep root systems and lacy foliage, which would not compete with their field crops. An obvious choice for this region would be babul (*Acacia arabica*).

India is a comparatively windless country. This probably explains why shelter-belts and wind breaks have hardly been used in our farming and horticultural techniques. They have occasionally been used in the tea plantations. I think that the formation of shelter-belts on the north Indian plains, especially in the arid tracts of Rajasthan, where wind erosion is a major factor, deserves careful consideration. American, Russian and Danish experience with shelter-belts has been remarkably satisfactory. Shelter-belts have been effective in controlling direct damage by high winds, preventing scorching and desiccation by hot winds, and prolonging the period of growth, all of which lead to higher yields, despite shade and root competition over a narrow strip along the belt. A good deal of research work has been devoted in Denmark to the study of the best type and dimensions of shelter-belts. It seems to me that this is a direction in which useful work might be done under the auspices of the Soil Conservation Society.

The notion that land capability classification should be based primarily on the degree of slope is no doubt generally valid, but there are cases where it is not the slope, but the specific vulnerability of the soil that should decide the use to which it should be put. In western Rajasthan, for example, it would be clearly unwise to disturb the soil for raising field crops even where the land is flat, for the essential requirement here is to keep the land under permanent vegetation so as to prevent the sand being exposed and being lifted up and deposited elsewhere to form sand dunes. Here the proper land use is pasture or ranching, not fitful agriculture. Again, the ravine lands of the Chambal and the Jumna have been carved out of flat lands. The cause of the mischief lies not in the slope of the land, but in the clearance of the fringing forest for agricultural purposes. This land has been built up by successive alluvial deposits of varying particle size, each layer with a different degree of erodibility, and is often ribbed with resistant strata of kankar. As soon as the protective mantle of protective vegetation is destroyed, erosion sets in and the variations in erodibility of the successive layers, gives rise to spectacular gully erosion often of fantastic shapes. As settlement along these rivers dates from very ancient times, this evil is very old. It seems to me that the only way to prevent the spread of this type of erosion is to restore the fringing forest along the river margins.

We should take advantage of the Vana Mahotsava movement to forward the aims of forestry in village lands. The time has now come to give a practical turn to this ceremonial planting, by persuading rural communities to plant, not occasional, individual trees, but compact blocks of land which may be available. The help and co-operation of the National Extension Services should be sought for this purpose. One essential element of success in this work is to make seeds, planting stock and technical advice readily available to the farmers.

Agronomy in Soil Conservation*

—by J. S. PATEL

THE erosion of soil has been an acute problem since man learnt to use the axe and the first crude plough. Though the erosion of land has affected the destinies of nations and civilizations, its influence on the lives of men was not clearly recognized till the pressure on land became acute and the farmers were reduced to the precarious subsistence farming. Man, who used to depend principally upon the animal food for his calorific requirements, was gradually compelled to change over to cereals and ultimately to tubers, because disregarding the growing population he abused and mined the land which is nature's gift and an irreplaceable resource. A permanent agriculture is possible only when people are willing to protect the land and meet the cost of such protective measures.

Before the march of land occupation in Chotanagpur the soil sustained vegetation and vegetation protected soil; rivers ran clear and in general water tended to move slowly over the ground surface. Now these lands are riddled with gullies; and the slopes which were once covered with forests, now lie bare and naked. Erosion has replaced favourable soil with unfavourable sub-soil and has created a new plant environment in which the original type of vegetation is markedly altered. This flagrant abuse of land continues to affect potential wealth and living standard of the people. The rich top soil, so very essential for human life, is being

* Presidential address delivered at the "Agronomy in Soil Conservation" Section of the Third Annual General Meeting of the Society held at Patna from 26 to 28 December 1954.

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eroded with water and wind either because of man's greed, ignorance, social customs and laws. Considerable areas are flooded every year and the rich soil is carried to the Bay of Bengal. More fertility is removed from the soil through erosion than is added by manuring and fertilization. With the fall in the productivity of the land, subsistence or sub-marginal farming has grown up. Thus, in Bihar, we have a striking contrast of fertile lands of north Bihar built up as a result of erosion elsewhere and Chotanagpur becoming poorer day by day through this same process of soil erosion. Whereas our fertile areas of north Bihar support a very dense population, those of Chotanagpur carry a sparse population.

The agronomist who is called upon to prevent the movement of surface soil, to control and conserve water and to restore and sustain soil fertility has to face in India some of world's most difficult problems arising out of torrential rains during a short rainy season, small fragmented holdings, extreme pressure on the land, economic inability of farmers to adopt land-use practices, and the absence of adequate knowledge of soil-improvement methods suited for the varying needs of the country depending upon the rainfall, topography, and the soil.

The agronomist has to advise about the overall farming systems to be adopted, keeping in view the integration of crop husbandry as well as the animal husbandry including the management of the grazing areas. He has also to consider the needs of the farmer as regards the food, economic return, and availability of labour and bullock power and irrigation resources. The elemination of peaks and troughs in the labour-employment is also an important consideration.

Having evolved an appropriate farming system, he has to recommend suitable crop-production techniques for different crops so that the income from farming is pushed up along with the maintenance of soil fertility. In this task he has to secure the advice of the soil-scientist, plant-breeder, plant-protection specialist, animal husbandry-man, soil conservation engineer, agrostologist, forester, and the administrator.

The peoples, animals, crops, grasslands and trees in India subsist on a declining resource. The dumping of surplus population on land which has been going on for long has to be stopped, and the pressure of population on land has to be reduced. A reduction in the numbers of livestock is an urgent necessity for improving the livestock as well as the grazing grounds.

Reconnaissance soil surveys have just commenced in most of the States in India and soil conservation surveys have not been attempted at all in many States. Adequate data on the erodibility of the land are not available. A study of the vegetation suitable for gully control, for stabilizing the field waterways for diversion ditches, for buffer strips, for wind-breaks, for pastures and for cover crops is practically a virgin and unexplored field. While soil conservation surveys are being conducted and the usefulness of different agronomical practices in soil and water conservation are being evaluated, contour bunding and contour cultivation need to be taken up immediately. In Chotanagpur bench terraces are very common for rice cultivation, but *tanr* or high lands suffer from sheet erosion which can be checked by contour bunds. A programme of bunding in Chotanagpur will not only improve the fertility of the soil, but will also improve the moisture-status of the land. Consolidation of holding will have to be taken up before the contour bunding.

Generally rotations are adopted as a result of economic need rather than because of real appreciation of its value in preserving productivity and maintaining crop yields. Farmers often adopt a rotation because they need a particular crop for their family or because the adoption of a rotation enables them to manage a larger area with less labour and bullock power, or because it provides sustained employment over a longer period.

Rotations in the past had been established according to accumulated experience and have been determined by soil type, climate, rainfall, topography, type of live-stock, occurrence of diseases and pests, price of agricultural produce, availability and cost of labour. In addition to these considerations, the rotation must aim at (a) improving the physical condition of the soil; (b) maintenance of organic matter and water holding capacity; (c) control of weeds, pests and disease; (d) prevention of soil erosion and leaching; and (e) building up of soil fertility.

Recommendations for adoption of rotations have widely figured in the extension programmes of the Department of Agriculture, and even where a conscious effort

has been made to introduce rotations, the spread of the practice has been rather slow.

Since the benefits accruing from the crop rotations are not as readily apparent and as spectacular as the benefits from the application of fertilizer or from the adoption of improved variety or improved cultural technique, it is necessary to organize a sustained drive for the introduction of rotations. The Departments of Agriculture are used to seasonal demonstrations but to popularize the rotations, biennial and triennial demonstrations will have to be arranged ensuring the continuity of supervision. Such demonstrations will have to be much more carefully planned and will call for a closer association of the farmer both at the planning stage as well as during its continuance. The results will have to be evaluated not only in terms of produce but also in money value. The consolidation of holding, tenancy reforms and introduction of high crop production techniques will assist in the wider adoption of rotations.

In India, the rotations are generally so arranged as to provide a recurrent succession of deep and shallow rooted crop or of legumes and non-legumes. The agronomists, as yet, have not evolved rotations based on a succession of a cultivated or inter-tilled crop, the non-inter tilled small grain crop and a grass legume mixture. Till the fertility of our soils is considerably improved, the introduction of a grass legume mixture in the rotation cannot be thought of because of economic reasons.

The choice of the legume and its place in the rotation is a very important consideration. Many of the commonly accepted notions regarding the usefulness of legumes, need reconsideration. Parr and his workers have found that berseem shows a striking response to phosphatic manuring as large quantities of phosphates are taken up and more nitrogen is fixed. The possibility of using berseem as green manure is, however, limited to such areas where irrigational facilities exist. This practice has to be evaluated against the practice of raising irrigated green manure in summer or of raising an early kharif green manure. The work in Bombay has shown that a legume grown in the rabi benefited the next kharif cereal, but a kharif legume did not benefit the rabi cereal. For example, paddy after *Dolichos* and bajra after gram gave higher yields of legume as well as cereals, provided pulses were manured with phosphates. On the other hand when ground-nut or moong were followed by rabi wheat or jowar, there was no beneficial effect even when phosphates were applied to the kharif legume. Similar results have been reported from Egypt. At Coimbatore, it has been observed that cluster beans (Gowar) are most beneficial for irrigated jowar whereas *Dolichos* and cowpea did good to the rainfed jowar. Soyabean, moong and cowpea did more harm than good when they preceeded Coimbatore cotton in summer. Preliminary experiments in Bihar have shown that growing of kharif kalai or urid benefited the rabi cereals and the rabi gram manured with phosphates benefited the kharif cereals. Peculiarly enough on the calcareous soil at Pusa a sixteen-year old rotational experiment has shown that maize after wheat yielded more than maize after peas or arhar or barley. Rotations will naturally depend upon the soil-type and the rainfall or irrigation facilities. It is clear there is much still to be learnt.

In India for 250 million acres of cultivated land about 1250 million tons of compost or farmyard manure are required at the rate of 5 tons per acre. The gross output of farmyard manure is estimated at 500 million tons of which roughly 250 million tons may be estimated as available for manure. This deficit of a thousand million tons of manure has to be made up largely through green-manuring. Though the importance of green-manuring has been recognized, for very long, practically no progress could be made in the field of green manuring because of many practical difficulties which the cultivator has to face. Where the moisture is available, because of the pressure of population and the subsistence farming, the cultivator prefers to raise a profitable cash crop rather than a green-manure crop. In many places, it is not possible to raise a green-manure crop during the off season because of high temperature or limiting moisture. Even if the green manure can be raised during the off season, moisture is required for its proper rotting. The seeds of green manures are in short supply and the cultivators are used to depending on others for supply of green-manure seeds. The foremost necessity, therefore, in the field of green manuring is to find varieties and species of green manures which can fit in with the

needs of the cultivators which may be summed up as follows:

(i) Quick growing green-manure plants which can be sown with the first rain and utilized as green manure before the transplanting of paddy is done.

(ii) The growing of such plants as can be grown along the bunds of the paddy fields without affecting the paddy crop. Such plants could be buried in the standing crop of the paddy or after the harvest of paddy.

(iii) Location of green-manure crops which can be sown either as "paira" or in the spring, and which can withstand the summer, are not grazed by cattle and be ready for ploughing in at the onset of the monsoon.

(iv) Green-manure shrubs which may be grown on waste lands and branches of which may be lopped off and applied during the rainy season.

For popularizing the green-manuring crops, social and legal measures are necessary on the following lines:

(i) Consolidation of holding;

(ii) Prevention of cattle tress-pass;

(iii) Compulsory growing of green manure crops in irrigated areas;

(iv) Concessional water rates for growing of green-manures;

(v) Supply of cheap green-manure seed;

(vi) Organization of the multiplication of green-manure seed; and

(vii) The evolution and supply of implements suitable for burying the green-manure plants in the soil.

Since green manure has often to be raised in the beginning of the monsoon or at the end of the monsoon season, it frequently fails and, therefore, the spread of the green manuring practice is very slow. Green manuring at present is confined to paddy, sugarcane, wheat and plantation crops, like tea and rubber.

Cover crops are only used in plantations of tea, coffee and rubber, under conditions of high rainfall and topography favourable for soil erosion.

Because of various reasons, the agronomy of cotton and sugarcane received earlier attention of the research workers than the agronomy of rice. Even now, the agronomy of pulses is almost an unexplored field. There are hardly adequate data regarding spacing, manurial and cultural requirements of pulses. There is need for varieties of pulses with wider adaptability to sowing dates and variations in the rainfall. Both introduced and wild legumes need to be evaluated for their suitability as soil builders during the rainy season, as over a very large tract the moisture during winter become so critical that a pulse crop cannot be raised without irrigation.

For popularizing the cultivation of the new or little known or unpopular legumes and for promoting the raising of green-manure crops, inducement will have to be offered to the cultivators. Wherever, direct subsidy on acre basis is not possible, indirect subsidies such as cheap seeds, cheaper phosphatic manures for application to legumes and reduced land and water rates are worth considering in this connection. Subsidies for promoting the cultivation of legumes are justifiable on the same grounds as subsidies on town compost, rural compost, oil cakes and phosphatic fertilizers. During the economic depression of 1930's, the Government of U.S.A. reduced the surplus production by encouraging the growing of grass and legumes with the assistance of subsidies and price incentives. It appears that part of the record production which was obtained in the U.S.A. during the war years was due to the built up fertility during the years of depression. As the agricultural production increases in this country, the Government will be faced with the problem of maintaining prices and restricting production. It is now, therefore, opportune for the Governments to consider plans for promoting cultivation of legumes and fodders. In experimental areas, pilot projects may now be taken up to gain experience required for the proper administration of such a scheme.

As a part of the programme for restoring soil fertility, it is necessary to promote investigations of practices involving simultaneous growing of two or more crops in mixed condition in a field. Ways and means for promoting the cultivation of mixtures will have to be found.

Since a very large acreage is under paddy where monoculture is practised year after year, with the introduction of "Japanese Method of Paddy Cultivation" it will be very opportune to think of introducing the cultivation of green manure, or of suitable fallows or of cultivation of grass where water logging does not occur. Such diversification is also desirable because it will make more water available for the remaining paddy

lands. Owing to high price of rice, the acreage under paddy has increased with a consequent scramble for the limited supply of water. This is a very favourable condition for the canal administration to introduce a cut in the supply of water for paddy and to alternatively offer earlier water for raising a green-manure crop. The land which is green manured in the kharif may be utilized for growing irrigated wheat. The percentage of cut, and the floor acreage to which it would apply need to be worked out carefully. The cut may progressively increase for those having higher and bigger holdings. As an inducement to make the cut acceptable, the rates may be so adjusted that the total irrigational rate both for the kharif and the rabi season does not exceed the rate for paddy irrigation. A scheme of this type offers scope for better utilization of water, reduction of pressure, and opportunity for building up soil fertility. The employment both for the labour and the bullocks will be better and peak loads for paddy transplanting and harvesting will be reduced.

Perhaps for the management of the canal, it might be more convenient if say $\frac{1}{3}$ or $\frac{1}{4}$ of the villages by rotation do not grow paddy once in three or four years and instead raise a green manure crop and irrigated rabi wheat.

To ensure that irrigational water is fully utilized, the Government may impose a condition that those who take irrigational water should adopt Japanese Method of Paddy Cultivation according to the prescribed scale which may gradually be raised to cover the entire irrigated paddy area.

Unfortunately, very little work has been done with regard to the water requirements of crops in this country. Much of the experimental data is unreliable because either the supply of water was not properly measured, or the intervals or frequency of irrigation were determined without reference to the need of the crops and consideration of the climate and soil types or without making proper allowance for the lateral spread of irrigational water. While the irrigation of sugarcane and cotton have received some attention important crops like rice and wheat have received little attention. Hardly any attempt has been made to study the proper rotation under irrigated conditions and to assess the water requirements of the entire rotational cycle.

In the past, so much attention has been devoted to the medium and short-term problems that long-term studies have been almost entirely neglected. While there are considerable data available for commercial or cash crops, very little data on the manurial requirements of non-cash or non-commercial crops are available. For example, the entire field of studies of minor millets, minor oil seeds, pulses and fodders and condiments is almost unexplored.

Only a few permanent manurial experiments are now being conducted in this country. Permanent manurial experiments are difficult and cannot be easily carried out on cultivators' field and, therefore, when they are carried out on experimental farms, it is essential to ensure good cultivation, recording of entire harvest and continuity in the policy. Now that manurial experiments are being conducted extensively throughout India on cultivators' fields and the consumption of fertilizers is rapidly rising, it is essential to provide a large number of reliable permanent manurial experiments so that should the question of degeneration of soil arise, the answer will be readily forthcoming.

In Bihar manurial experiments on cultivators' fields have been carried out on a large scale on a variety of crops. These experiments have helped in locating pockets which are difficient in phosphates and potash, and have convinced the cultivators of the usefulness of the fertilizers.

With the provision of credit facilities for securing the fertilizers and with the increasing awareness to the usefulness of the fertilizers, larger doses will be applied to the fields than hitherto. The need for balanced manuring will be all the more greater under these altered circumstances. While it is undesirable to promote the use of fertilizers which do not show crop response, it is not correct to ignore the deficiencies which have already been noticed. The use of phosphatic fertilizer is gradually increasing but the consumption of phosphatic fertilizers bears no proportion to the consumption of ammonium sulphate. Recent experiments in Bihar have shown that there are pockets where potassium is the main limiting factor. The use of potassium in such areas will have to be popularized with the aid of subsidy.

Liming of soil is practically unknown in the country and one of the handicaps in popularizing the use of lime has been that

the benefit from the application of lime is not immediately reflected in the crop yield. To popularize liming, demonstrations will have to be conducted on the same land for over three years in succession. The non-availability of cheap lime and the high railway freight are likely to prove a handicap in extending the use of lime in agriculture. If ground limestone can be offered at reduced prices, it might encourage the liming habit without the risk of diversion of ground limestone for constructional purposes.

There has been inadequate experimentation both on Government farms and on cultivators' land with trace and minor elements. There is as much risk involved in excess application as in deficiency.

The responsiveness of existing varieties to heavier doses of fertilizers application has to be systematically tested. With the introduction of the Japanese Method of Paddy Cultivation, this problem has come into the forefront. Because of lodging, some of the improved varieties have not been able to stand up as well to heavier manuring as some of the indigenous varieties. The plant breeders in the past have endeavoured to breed the varieties to suit the poor fertility status, but now they should evolve varieties to suit high fertility.

The progress in the field of agronomy in India has been influenced by the back-ground of the research worker and his ability to convince those in authority of the usefulness of the problem as well as the capacity of the Department of Agriculture to translate the result of the research into field practice. The organizational set up of the Department of Agriculture and the financial resources available to the cultivators have often determined the choice of the research problem.

Those with Western training have endeavoured to emphasize the analytical and scientific aspect of cultivation while those who were not subject to this influence and were trained on the farms have emphasized the skills of agriculture and the art of combining the various factors of production. While plant breeders and agricultural chemists have managed to impress the practicalists with their achievements, the former have failed to take a significant interest in the claims of the practicalists. What could not be explained in terms of known theories of the science has often wrongly been interpreted as an art and has been severely left alone by the research workers.

The agronomical investigations all over India have dealt with the problems of "spacing and manuring" and a combination of these two factors. The line plantings had to be necessarily resorted to for carrying out these experiments. Even with the application of high dozes of fertilizers comparatively closer plantings were found to yield more. Despite these findings, on the introduction of the Japanese Method of Paddy Cultivation it has been observed that heavy manuring and wider planting when combined with suitable inter-cultural technique gave the maximum results. Here is an instance where the experimenters had for a long time missed the significance of the art of cultivation.

From the same field with a given variety and a manurial schedule one farm manager produces a better crop than another though both are keen and honest. The better manager provides harmonious combination of factors of production and consequently secures a better out-turn. The judgement regarding the proper tilth, soil moisture and the timing of the operation being superior he is at an advantageous position. Because a uniform standard for tilth, soil-moisture and the timing of the operation has not been evolved, the experimenter has neglected this fruitful field of study. A good crop is, therefore, often regarded as something ununderstandable because it is due to a combination of factors. In our urge, to study the effects of single factors, we are apt to ignore studies involving the large number of factors because factors are complex, difficult to analyse and evaluate.

While it has been universally recognized that certain groups of farmers such as "Koiris" are very skilled in the production of crops, their methods of production have not been carefully recorded and evaluated. Similar specialist groups are to be found all over the country and much wealth of useful materials is not exploited because of lack of interest in the indigenous methods and technique. While recognizing the importance of seed, manure and irrigation, we had ignored the fourth important factor namely the art of cultivation.

The use of land depends upon the needs of the society and financial resources of the farmer, knowledge and skill of the cultivator

and social customs. Therefore, rapid changes in the land-use pattern cannot be expected but it would be wrong not to propagate the concept of land use, and to take advantage of the increasing productivity for initiating land-use planning. A start will have to be naturally made with the advanced and comparatively better farmer, but unless a start is made, the second step cannot be taken.

Survey and Planning for Soil and Water Conservation*

by F. W. PARKER

Introduction

I APPRECIATE the opportunity of attending the Third Annual Meeting of the Soil Conservation Society of India and participating in the programme.

Your officers kindly invited me to preside at this session and to briefly discuss " survey and planning for soil conservation", which is the general subject for the session. I propose in my remarks to offer suggestions about soil and water conservation in India. Before doing so, I will first tell you something of my qualifications for giving suggestions on this subject.

I have observed, or been associated with, the soil conservation programme in the United States for a period of more than twenty years. During the first half of that period, I was not associated with any governmental organization but travelled extensively and had an opportunity to observe the development of a soil and water conservation programme under the sponsorship of the U.S. Department of Agriculture, which involved the participation of the several states, farmers, and the public at large. During the latter half of the period, I was associated with the U.S. Department of Agriculture, with responsibility for a major portion of the soil, fertilizer and irrigation research of the Department.

My experience in India has been limited. I have spent less than two years in this country but have travelled fairly extensively. Most of my contacts with soil and water conservation problems have been rather superficial. I am sure, therefore, that you will agree that my qualifications for comments on survey and planning have limited value and are based more on observations in the United States than in India. There is one further qualification, I am limiting my domain to soil and water conservation on agricultural land. The importance of forests is recognized, but I am not qualified to discuss that phase of the subject.

The Indian Situation

It may be helpful to briefly review the soil and agricultural situation in India. The last census indicated that for every 100 acres of arable land there were 100 people, 70 of them engaged in agriculture. In addition, there were 60 to 70 animal units which derived a major portion of their feed from arable land. It has been estimated that by 1980 there will be 135 people for every 100 acres of arable land, and it is quite possible that 95 of the 135 will be engaged in agricultural pursuits. Such figures indicate the high and growing pressure of population on the land.

The average crop yields in India are very low. At the same time, the work of agricultural institutions and cultivators shows that the potential crop yields are quite high.

* Presidential address delivered at the " Survey & Planning " Section of the Third Annual General Meeting of the Society held at Patna from 26 to 28 December 1954.

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In fact, there is good reason to believe that potential crop yields in India are just as high as in other countries.

A most significant and rather recent development is the awakening of cultivators and the rapidly expanding rural development. This is centered in the Community Projects and National Extension Service. It involves an awakening interest and progress in agricultural production, health, education, and other aspects of community development. It is gaining momentum and will create demands for new knowledge, new practices and technical services that will not be easy to meet.

This very brief review of the Indian agricultural situation indicates the high degree of dependence on soil and water resources. The awakening cultivators will demand guidance and assistance in so handling these resources that their standards of living may be improved.

Definition of Soil and Water Conservation

In ordinary terminology, conservation is usually understood to mean saving, frequently by limited use. That was the concept of some conservationists in the United States when the soil conservation programme was initiated during the depression of the 1930s. It was a question of saving the land more than using it. Gradually, during the last twenty years the concept has broadened. The present concept has been stated by Dr. Salter, recently Chief, Soil Conservation Service, as follows:

> " The concept of soil conservation has come to mean proper land use, protecting the land against all forms of soil deterioration, rebuilding eroded soil, conserving moisture for crop use, proper agricultural drainage and irrigation where needed, building up soil fertility, and increasing yields and farm income — all at the same time.
>
> " Modern conservation farming involves increasing soil productivity and increasing standards of farm living for today, tomorrow, and for posterity. It combines the objective of national welfare with better living for the people who work the land. It has come to mean efficient, abundant production on a sustained basis."

If we consider the matter of terminology and definition for India, I would be inclined to use the term " soil improvement " rather than " soil conservation ". " Water conservation ", of course, is an excellent term, but applied to soils the term " conservation " does not appeal to me as strongly as the more positive term " improvement ".

If we accept the foregoing definitions of soil conservation, we must also recognize the complexity of the problem and measures to cope with it. Real soil conservation in India will involve water management, the use of fertilizers and green manures, the management of livestock, changes in cultural practices, consolidation of holdings, and improved credit and marketing facilities.

Suggestions for Your Consideration

Give full recognition to the complex nature of soil conservation and plan programmes and organizations accordingly. Initially, this was not done in the United States, with the result that the programme was handicapped for a number of years. As the true nature and complexity of soil conservation was appreciated, the programme and organizations to develop and direct the programmes were changed. India could profit a great deal by carefully studying the mistakes that were made in the United States and steps that were taken to correct them.

Remember that with minor exceptions the cultivator will apply the soil and water conservation practices on the land. He may have the benefits of research, extension, technical services, and credit facilities but in the end the practices must be put into effect by the man on the land. He must be convinced that a suggested improvement is a good thing.

Assemble and evaluate the known facts about the practices that need to be adopted to conserve and improve soils. India should make full use of the substantial body of knowledge developed in this country and the accumulated knowledge of other countries. The latter is readily available under the technical assistance programmes of the United Nations, the United States, and the Colombo Plan. Drawing on this vast body of knowledge will save money, manpower and, most important of all, it will save time.

Provide strong agricultural extension and information services. A recognition of the need for soil conservation is a prerequisite to the adoption of improved practices.

Securing recognition and appreciation of this need is an educational process. India should utilize every means and agency at its command to present the soil and water conservation problems to both rural and urban people. It is only when these needs are fully recognized that the public will support the programme and the necessary measures to be taken to bring about the desired changes in practices. Most of this task should be a function of the agricultural extension and information services of the Centre and States.

Provide the technical services that have been found to be essential. The extension and information programmes must be supplemented by technical services to the cultivator. These services will include irrigation and drainage engineering, soil testing, and farm planning. It will require the services of a large number of agronomists, soil scientists, agricultural engineers and farm planners. Fortunately, India has a good, though relatively small, corps of trained technicians. Many more will be needed. This, therefore, calls for an extensive training programme, which I understand has already been planned.

Provide good credit facilities. The adoption of soil conservation practices usually requires capital expenditure. Credit for such expenditure must be available. Publication last week of the "All-India Rural Credit Survey", with its very constructive recommendations, is convincing evidence that this important, though difficult, problem will be tackled with vigour and good effort. The Indian cultivator can look forward to having better credit facilities to enable him to adopt the soil and water conservation practices that are essential for efficient, abundant production on a sustained basis.

In conclusion, I suggest that this Society may subscribe to the same thesis as the authors of the "All-India Rural Credit Survey" stated in the closing sentence of the "General Report":

> "The larger thesis, in which our concrete recommendations can find place only as a part, is that what India most needs today in a comprehensive and determined programme of rural regeneration which has the ethical impulse and emotional momentum of its highest traditions; which has, moreover, the calculated design of a project that is scientifically conceived and scientifically organized; and which, above all, attempts to render to rural India, in the economic realm, those opportunities for growth and fulfilment which, without distinction between man and man, but with especial compassion for the weak and the disadvantaged, more than one religious leader at more than one period of the country's history attempted to render to the masses of India in the realm of the spirit."

Grassland in Soil Conservation*

by R. O. WHYTE

THE misuse of the grassland and fodder resources is probably the most important factor contributing to erosion in India. If it were possible to manage the grassland properly and also shift some of the livestock pressure on to the cultivated land, much of the damage caused by the excessive runoff from grazing land would be stopped. The shifting of livestock on to the arable land entails the adoption of mixed farming, a combination of food and cash crops with leguminous fodder crops, accompanied by the maximum return of animal fertility to the soil. On what minimum size of holding is mixed farming possible? At the Indian Agricultural Research Institute, it has been

*Presidential address delivered at the Section of "Grassland in Soil Conservation" at the Third Annual General Meeting of the Society held at Patna from 26 to 28 December 1954.

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found possible on an irrigated holding of $7\frac{1}{2}$ acres to produce food for the family, fodder for the livestock, and a surplus for sale. The same result was obtained with 5 acres irrigated at the Institute of Agriculture, Anand; they are now testing holdings of $2\frac{1}{2}$ acres at Anand, but this involves the sharing of a pair of working bullocks between four or five cultivators.

More studies of this kind are needed in the other regions of India. The fodder crops grown in the rotation should preferably be short duration legumes, to improve the productivity of the soil and produce high protein feed.

The grasslands of India, particularly within reach of villages are extremely degraded, unable to provide grazing for livestock or to conserve soil and water. We are now beginning to understand the grassland and to be able to recognize the many different types that exist. We are also noting the remarkable regeneration of superior grasses that occurs after protection from grazing for 2 or 3 years. Those preliminary observations are being confirmed by the I.C.A.R. grassland survey, now being carried out by a team of six over a period of 5 years. In addition to this rapid reconnaissance survey, more detailed studies of specific regions are being made by the Institute of Science, Bombay, and by Saugor University in Madhya Pradesh. There is a great need for more protected areas in which the survey team may study the ecological succession, and for runoff plots to compare the soil and water loss from different grassland types.

We now know enough about Indian grasslands to recommend measures for the gradual improvement of village pastures, by progressive closure of one-tenth of the area at a time, followed by carefully controlled grazing. It is now a matter of demonstration, persuasion and education. If, however, village pastures are to be no longer mere exercise grounds and are to be able to provide adequate grazing while also conserving soil and water, the rate of stocking must be reduced from three beasts per acre for the whole year to a beast for 2 acres for the post-monsoon grazing period of 4 months. That is the approximate extent of the overload on India's grazing grounds and the primary cause of the damage that is so wide spread.

Limitation of grazing to a 4-month period necessitates hand-feeding of fodders, crop residues and other feeds for many months of the year, either in yards or stalls. Pasture and fodder calendars require to be designed for all regions of India, indicating the type and amount of grazing and feeds which the animals may be given in each month of the year. The farm layouts and cropping patterns may be designed accordingly.

Very soon we will know the amount of fodder which can be provided from the cultivated land, plus the optional carrying capacity of India's grassland. Then we will be face to face with the inescapable fact that it is impossible to provide grazing and fodder adequate in quantity and quality for India's livestock population. That will be as far as the grassland ecologist and fodder agronomist can go. Beyond that it becomes a problem for India herself to deal with its cattle problem. They are the chief contributors to the erosion problem in the country. India has to choose between its cattle and its soil.

A review of "The Grassland and Fodder Resources of India" which I have just completed will be published as I.C.A.R. Monograph in 1955. Those sections of particular interest to foresters will appear as an Indian Forest Record, entitled "Forest Grazing in India".

Annual Report of the Soil Conservation Society of India for the Year 1954

THE Second Annual General Meeting of the Society was held at Poona on December 28-31, 1953. Sri Morarji Desai, Chief Minister, Bombay State, inaugurated the opening session and Sri B. S. Hiray, Minister for Forests and Agriculture welcomed the guests and delegates. The inaugural session was attended by representatives of the T.C.M., Ford Foundation, D.V.C., C.W. & P.C., and distinguished persons of Poona besides the members of the Society and delegates to the session from the various States.

The session was divided into five sections which were presided over by experts in the respective fields of soil conservation. A detailed report of the session has been published in our Journal, Vol. II, Nos. 2 and 3 (January and April, 1954 issues). The session was organized by committee consisting of Sri L. S. S. Kumar, Principal, Agricultural College, Poona, as Chairman and Sri M. K. Shirole, Divisional Soil Conservation Officer, Bombay State, as Secretary.

The plenary meeting of this session which was held on the last day was presided over by Sri H. M. Patel, I.C.S., Secretary, Ministry of Food & Agriculture, Government of India. Several resolutions as adopted have been published in the April 1954 issue of the Journal.

Membership

The number of members up to the time of the second annual meeting was 316. All of them were admitted as members by the consent of the General Body. Of the 316 members on the roll in 1953, 55 members could not continue their membership due to various reasons. The Society, however, has received requests from 20 of them to renew their membership. We have since enrolled 178 members of which 6 are life members and the rest ordinary up to the 15th December 1954. All of them have been admitted as members. (The list of members has been published in the Journal from time to time.)

The Society is grateful to all members for their co-operation in enrolling interested persons in soil conservation as members of the Society. Special mention may be made of the valuable efforts of Messrs K. S. V. Raman, I.C.S., Dr. J. K. Basu and M. K. Shirole in the membership drive. The Society will appreciate if all its members take active interest in bringing home the objective of the Society to persons in all walks of life by personal contacts, popular lectures and distributing pamphlets.

Amendments to Rules of the Society

During the plenary session of the Society under the presidentship of Sri H. M. Patel, I.C.S., the list of members enrolled in 1953 was presented for admission to the Society by the consent of the General Body. The President rightly recommended that there was considerable delay in the admission of members on account of the practice of admitting them by a consent of the General Body or the Council of the Society. He suggested that the power of admission of members to the Society be vested with the Secretary. The proposal was unanimously accepted by the General Body. Accordingly rule No. 9 was amended to read as follows:

> "Members shall be admitted by the Secretary if proposed by a member and seconded by two other members. The honorary members shall be recommended by the Council for election at a general meeting. Associates shall be admitted at the discretion of the Secretary."

In accordance with the above amendment all the members enrolled in the year 1954 have been admitted to the Society by the Secretary.

Council of the Society

The term of the present Council of the Society consisting of 18 members as in Appendix I expires with the end of this year and the new Council has to function

from the 1st of January 1955. The present Council was of opinion that due to the wider activities of the Society and the greater volume of work involved the future Council should have its full strength of 25 members. It was also decided by the present Council to invite proposals for a new Council by post from all members and accordingly the Secretary called for proposals for 25 members of the future Council from all the members in his circular letter dated 27th October 1954. The last date for the receipt of proposals was fixed on 25-11-1954. A total of 47 valid proposals were received. The tabulation of the results show that a total of 71 members were proposed for the future Council. Of this 25 members who have received the maximum number of proposals have been selected. A list of these members is shown in Appendix II. They are hereby declared elected as the new Council members of the Society from January 1955 to December 1957. They are requested to elect among themselves the office bearers of the Society as per rule No. 14.

The Society places on record its deep appreciation of the valuable and enthusiastic work rendered by the out-going Council members for bringing it to its present status. It also takes this opportunity to welcome the newly elected Council members who, it is hoped, will not spare any pains to make the Society to achieve its objectives for which it has been formed.

Government Grant for the Working of the Society

A recurring grant of Rs. 2,000 has been sanctioned by the *Indian Council of Agriculture Research, New Delhi*, to the Society in response to the Society's application to the Ministry of Food & Agriculture, Government of India, New Delhi. The Society is grateful to the Ministry for this grant.

The Society had also approached all State Governments to sanction a recurring grant of Rs. 1,000 per year for meeting the expenses of the Society and keep up its all India character.

Replies from 10 States have been received. Of these a few States have refused and 25 States are still considering the sanction of the grant. It is hoped that most States will agree to sanction the recurring grants. Delegates from the various States are requested to kindly persue the matter with their respective State Governments.

Donations

The Government of Bombay had kindly sanctioned a sum of Rs. 1,000 to meet the expenses of the Society in the Second Annual Meeting held at Poona on 28-31 December 1953. The Society is grateful to the Government of Bombay for this.

Journal

During the period under review we have published 4 issues of the Journal of Soil & Water Conservation in India. It has been the effort of the Editor to make the Journal informative and educative in the field of conservation of soil and water as well as to maintain its standard at a level which will interest both the scientists as well as the laymen. It has been gratifying to note that the interest of the scientists and scientific organizations both in India and abroad in the activities of the Society and its Journal is considerably increasing. Besides, we have received a large number of journals in exchange which have been acknowledged. The list of journals which we are receiving in exchange have been published in the Journal from time to time.

We are sending a large number of complementary copies of our Journals to all Indian Embassies abroad for wide publicity and the response is encouraging. In addition to this we are sending complementary copies to all educational institutions in India and to the State Governments. The latter have since been requested to subscribe to the Journal.

Accounts

The accounts of the Society for the year 1954 have been compiled by the Treasurer of the Society and audited by Sri A. R. Ghosh, Accounts Officer, Damodar Valley Corporation, Hazaribagh. They are presented in Appendix III. The Society extends its deep appreciation to Sri Ghosh for his honorary services.

Budget Estimate for 1955

The details of budget estimate for the year 1955 are presented in Appendix IV.

A. A. HAKIM

APPENDIX I

PRESENT COUNCIL

General President — SIR V. T. KRISHNAMACHARI, K.C.S.I., K.C.I.E., Member, Planning Commission

Chairman — DR. J. K. BASU, M.Sc., Ph.D. (Lond.), F.N.I., Director of Soil Conservation (Agriculture), Government of India, New Delhi

Secretary — MR. A. A. HAKIM, B.E. (Hons), C.E.M.S. (Ill., U.S.A.), Executive Engineer, D.V.C., Hazaribagh

Treasurer — MR. S. S. PILLAI, Superintending Engineer, Mechanized Earthmoving Circle, D.V.C., Hazaribagh

Editor — MR. K. S. V. RAMAN, I.C.S., Development Commissioner, Bihar, Patna

Asst. Editor — MR. P. G. SINHA, Administrative Officer, Soil Conservation Department, D.V.C., Hazaribagh

Members of the Council

1. MR. J. BANERJI, I.F.S., Chief Conservator of Forests, Andamans, Port Blair
2. DR. S. P. CHATTERJEE, M.Sc., Ph.D. (Lond.), D. Litt. (Paris), Head, Department of Geography, Calcutta University, Calcutta
3. MR. M. D. CHATURVEDI, I.F.S., Inspector General of Forests, Ministry of Agriculture, New Delhi
4. MR. V. S. KRISHNASWAMY, I.F.S., Conservator of Forests, Salem Circle, Salem, Madras
5. MR. H. K. NIVAS, I.S.E., M.I.E., Superintending Engineer, South Bihar & Chotanagpur Waterways Circle, Patna
6. MR. S. S. PRASAD, I.F.S., Chief Conservator of Forests, Bihar, Ranchi
7. DR. S. P. RAYCHAUDHURI, Ph.D. (Lond.), D.Sc. (Cal. & Lond.), F.R.I.C., Head, Division of Chemistry, I.A.R.I., New Delhi
8. SRI S. C. ROY, Director of Extension Service, Ministry of Food & Agriculture, Government of India, New Delhi
9. MR. D. D. SAIGAL, I.F.S., Chief Conservator of Forests, Vindhya Pradesh, Rewa
10. DR. A. B. S. VERMA, B.Ag., M.Sc. (Agr.), Ph.D. (Purdue), Soil Conservation Officer, Madhya Pradesh, Hoshangabad
11. MR. A. N. KHOSLA, I.S.E., (Retd.), Ex Chairman, C.W. & P.C. and Ex Additional Secretary, Ministry of Irrigation & Power, Government of India
12. MR. VISHNU SAHAY, I.C.S., Secretary to the Government of India, Ministry of External Affairs

APPENDIX II

NEW COUNCIL

1. SRI K. S. V. RAMAN, I.C.S., Development Commissioner, Bihar
2. SRI S. S. PRASAD, I.F.S., Chief Conservator of Forests, Bihar
3. DR. J. S. PATEL, Director of Agriculture, Bihar
4. Sri J. N. PANDEY, M.S. (Agri) Cornell, Ph.D. (Edin.), F.A.Sc., Divisional Forest Officer, Afforestation Division, Bihar
5. SRI S. SITARAMAN, B.E., C.E., A.M.I.E., M.R. San. I (Lond.), Superintending Engineer, Projects & Investigation Circle, Government of Bihar, Patna
6. SRI N. C. BOLE, M.Sc., Regional Planning Officer, Bihar, Patna
7. SRI P. P. VARMA, Member, Damodar Valley Corporation, Calcutta
8. SRI S. S. PILLAI, Director of Soil Conservation, D.V.C., Hazaribagh
9. SRI A. A. HAKIM, B.E., C.E., M.S. (Ill., U.S.A.), Executive Engineer, Headwaters Eng. Circle, Soil Conservation Department, D.V.C., Hazaribagh
10. SRI P. G. SINHA, Administrative Officer, Soil Conservation Department, D.V.C., Hazaribagh
11. DR. S. P. CHATTERJEE, M.Sc., Ph.D. (Lond.), D. Litt. (Paris), Head of the Department of Geography, Calcutta University

12. DR. S. PATTANAIK, Ph.D. (Cornell), Soil Conservation Officer, Orissa
13. DR. A. D. KHAN, Dy. Director of Agriculture (Soil Conservation), Uttar Pradesh
14. MR. D. A. GADKARY, Joint Director of Agriculture, Bombay
15. SRI H. M. PATEL, I.C.S., Secretary to the Ministry of Finance, Government of India, New Delhi
16. SRI P. N. THAPAR, I.C.S., Secretary to the Ministry of Food & Agriculture, Government of India, New Delhi
17. SRI C. R. RANGANATHAN, I.F.S., Inspector-General of Forests, Government of India, New Delhi
18. DR. J. K. BASU, M.Sc., Ph.D. (Lond.), F.N.I., Director of Soil Conservation, Ministry of Food & Agriculture, Government of India, New Delhi
19. SRI S. C. ROY, Agricultural Extension Commissioner, Government of India, New Delhi
20. SIR V. T. KRISHNAMACHARI, K.C.S.I., K.C.I.E., Dy. Chairman, Planning Commission, Government of India
21. SRI C. P. RAJU, Agricultural Engineer, Andhra
22. SRI BALWANT SINGH, Conservator of Forests, PEPSU
23. DR. R. J. KALAMKAR, Director of Agriculture, Madhya Pradesh
24. DR. S. P. RAYCHOUDHURI, Ph.D. (Lond.) D.Sc. (Cal. & Lond.), F.R.I.C., Head of the Chemistry Division, I.A.R.I., New Delhi
25. SRI V. S. KRISHNASWAMY, I.F.S., Dy. Conservator of Forests, Madras

APPENDIX III

STATEMENT OF ACCOUNT OF THE SOIL CONSERVATION SOCIETY OF INDIA FOR THE YEAR 1954

Receipts and Payments Account

SUBSCRIPTION FUND

Receipts	Rs.	as.	p.	Payments	Rs.	as.	p.
To opening balance	12,504	6	9	By honoraria	885	0	0
To subscription fund of life members	605	0	0	By postage	421	2	6
				By stationery	74	3	6
To subscription fund of admission fee	919	15	0	By Bank charges	24	10	0
				By advance for second session ...	500	0	0*
To subscription fund of membership	905	0	0	By expenses on second annual general meeting	353	3	0
To subscription fund of renewal membership	1,281	7	0	By contingencies	21	5	6
				By closing balance	14,995	14	9
To Bank interest	1,057	10	6				
To miscellaneous (Bank charges)	2	0	0				
TOTAL	17,275	7	3	TOTAL	17,275	7	3

*Adjusted in 12/54 account

JOURNAL FUND

Receipts	Rs.	as.	p.	Payments	Rs.	as.	p.
To grant from Central Government (I.C.A.R.)	2,000	0	0	To postage	407	3	0
				To advertisement commission ...	150	0	0
To advertisement	2,875	0	0	To printing of journal ...	6,351	9	0
To sale of Journal	166	0	0				
To cost of reprints	258	11	0				
To miscellaneous	93	8	0				
To amount withdrawn from subscription fund	1,515	9	0				
TOTAL	6,908	12	0	TOTAL	6,908	12	0

APPENDIX III—*Contd.*

DETAILS OF CLOSING BALANCE

	Rs.	as.	p.		Rs.	as.	p.
Imperial Bank of India, Ranchi...	11,010	4	6	Balance of subscription fund ...	14,995	14	9
Dr. V. Nath	102	12	6	Balance of Journal fund ...	−2,712	2	6*
Cash with Treasurer	143	3	3				
Cheque deposited in the bank but not credited in that month	1,027	8	0				
TOTAL	12,283	12	3	TOTAL	12,283	12	3

	Rs.	as.	p.
*Last year's	−1,196	9	6
Current	−1,515	9	0
	−2,712	2	6

Sd. S. S. PILLAI
Treasurer

CERTIFIED that the receipts and payments account have been checked by me and the same have been drawn up correctly from available records and I am satisfied with the same.

Sd. A. R. GHOSH
Accounts Officer
Damodar Valley Corporation
Hazaribagh

APPENDIX IV

BUDGET ESTIMATE FOR 1955

Income	Rs.	as.	p.	Expenditure	Rs.	as.	p.
Subscription from old members, 500 @Rs. 5	2,500	0	0	Pay of a full-time assistant @Rs. 150 p.m. for 12 months	1,800	0	0
Subscription from new members, 200 @Rs. 10	2,000	0	0	Books and periodicals for library	1,000	0	0
				Postage	1,000	0	0
Subscription from new life members, 10 @Rs. 100	1,000	0	0	Stationery	1,000	0	0
				Printing charges for 4 issues of Journal @Rs. 2,500	10,000	0	0
Sale of reprints of popular articles and Journals	200	0	0	Printing of reprints to authors and popular articles	1,000	0	0
Advertisement charges for 3 full pages @Rs. 1,000	3,000	0	0	Contingencies including pay of a part-time peon @ Rs. 15 p.m.	500	0	0
Income from investment ...	1,050	0	0				
TOTAL	9,750	0	0	TOTAL	16,300	0	0

Excess of expenditure over income ... ... Rs. 6,500 0 0

Report on the Third Annual General Meeting of the Soil Conservation Society of India Held at Patna (Bihar)

THE Third Annual Session of the Society was held at Patna from the 26th to the 28th December 1954, while the delegates after the session were taken out to visit Nalanda and Rajgir areas of the Community Projects of Bihar on the 29th December. A trip was also made to the Soil Conservation sites in the Damodar Valley around Hazaribagh on the 30th. They visited the Experimental Station at Deochanda, the receding water farm at Sewai, the Soil Conservation and Demonstration work site at Gonda and the Jamunia Head-water control dam-site at Bishungarh.

An organizing committee consisting of Sri H. N. Thakur, Deputy Development Commissioner, Bihar, as Secretary and Sri N. C. Bole, Regional Planning Officer, Bihar, as Deputy Secretary was formed for the session at Patna.

The Government of Bihar was pleased to sanction a grant of Rs. 1,000 to meet the expenses towards this session. The committee made adequate arrangements for the success of the session under the valuable guidance of Sri K. S. V. Raman, I.C.S., Development Commissioner, Bihar, and the Editor of the Journal of the Society.

The inauguration ceremony of the session was held at Darbar Hall of the Raj Bhawan, Patna, on the morning of the 26th December. Sri K. B. Sahay, Minister of Revenue and Forests of the Bihar State, welcomed the delegates. Dr. Srikrishna Sinha, Chief Minister, Bihar State, inaugurated the session. There was a large gathering of over 400 persons which included State Ministers, Members of the State Legislature, High Court Judges, Senior Officers of the Governments, representatives of the F.A.O. and T.C.M. and other distinguished visitors besides the members and delegates of the Society. A list of members and delegates is given in Appendix 'A'. The presidential address was delivered by Sri H. M. Patel, Secretary, Ministry of Finance, Government of India (lately Secretary of Food & Agriculture Ministry, Government of India). Sri Punjab Rao Deshmukh, Deputy Minister, Ministry of Food & Agriculture, Government of India, who had intended to attend the session and address the gathering could not come on account of some unavoidable circumstances. His address was read by Dr. J. K. Basu, Chairman of the Society. The welcome address, inaugural address and presidential address are published in this issue.

Many messages were received and some of them were read out by the Chairman of the Society. All the messages received are published elsewhere in this issue.

After the inauguration ceremony the session was divided into six sections. The sections and presidents were:

I. SURVEY AND PLANNING FOR SOIL CONSERVATION
President: Dr. F. W. Parker, Chief Agriculturist, T.C.M., New Delhi

II. AGRONOMY IN SOIL CONSERVATION
President: Dr. J. S. Patel, Director of Agriculture, Bihar

III. GRASSLAND IN SOIL CONSERVATION
President: Dr. R. O. Whyte, F.A.O., Grassland Adviser to Government of India

IV. FORESTRY IN SOIL CONSERVATION
President: Sri C. R. Ranganathan, I.F.S., Inspector General of Forests, Government of India

V. SOIL CONSERVATION ENGINEERING
President: Sri K. V. Ekambaram, I.S.E., Chief Engineer, Kosi Project

VI. SOCIAL AND ECONOMIC ASPECTS OF SOIL CONSERVATION
President: Sri K. S. V. Raman, I.C.S., Development Commissioner, Bihar, Patna

The meetings of these sections were held in the Conference Room of the Patna Secretariat. The arrangements for the stay of delegates and members were made in the Circuit House, Clubs, Dak Bungalow and various hotels.

All the sectional meetings were well attended and the discussions held were very valuable and useful. A number of scientific and technical papers were presented and were fully discussed in the meetings. A list of papers and their authors is given in Appendix 'B'. Light refreshments were served at each meeting.

The plenary session was held under the chairmanship of Dr. S. K. Basu who was also the chairman of the Society, on the afternoon of the 28 December. The annual report was presented by the Secretary and the names of the members elected for the new Council for 1955-57 were announced. The annual report is published in this issue. The various recommendations made at sectional meetings were passed as resolutions in addition to other resolutions which are given in Appendix 'C'.

Members and delegates were entertained at an evening party on 28th December by Sri R. R. Diwakar, Governor of Bihar (who is a Patron of the Society). He met all the guests in person.

The publicity was handled by the Public Relations Department of the Government of Bihar as a special case. Representatives of the Press, News Agencies, attended the session. Newspapers all over the country featured the proceedings of the Society. The All India Radio, Patna Station, arranged to record the proceedings of the inaugural ceremony on the 26th December which were subsequently broadcast in the evening over the All India Radio, Patna Station. The Organizing Committee is grateful to the Public Relations Department, Government of Bihar, and the All India Radio, Patna Station, for their kind help in giving wide publicity to the session.

H. N. Thakur
Organizing Secretary

APPENDIX A

Bihar

Ahmad, S., Technical Assistant to the Chief Conservator of Forests, Bihar, Ranchi

Alam, S. M., Patna

Bole, N. C., Regional Planning Officer, Bihar, Patna

Chhugani, A. D., Agricultural Engineer

Chowdhury, N. C., Asst. P.E.O., Bihar Sharif, Patna

Dutta, B. K., Secretary to the Development Commissioner, Bihar, Patna

Ekambaram, K. V., I.S.E., Chief Engineer, Kosi Project, Bihar, Patna

Hoda, N., Superintending Engineer

Hussain, I., Md.

Jha, C.

Mandal, S. C., Soil Survey Officer, Sabour, Bhagalpur

Mohammad, S., Forest Research Officer, Bihar, Ranchi

Mukherjee, H. N., Dr., Agricultural Chemist to the Government of Bihar, Sabour

Pande, B. D., I.C.S., O.S.D., Patna

Pandey, J. N., Divisional Forest Officer, Afforestation Division, Hazaribagh

Pandey, L. K., Divisional Forest Officer, Afforestation Division, Mazzaffarpur

Patel, J. S. Dr., Director of Agriculture, Bihar, Patna

Prasad, S. S., I.F.S., Chief Conservator of Forests, Bihar, Ranchi

Prasad, R., I.A.S., Development & Employment Secretary, Patna

Prasad, K. K., Pusa

Raị, U. N., P.E.O., Bihar Shariff

Ramanujam, S., Dr., Director, Central Potato Research Institute, Patna

Raman, K. S. V., I.C.S., Development Commissioner, Bihar, Patna

Rao, S. R., Executive Engineer, I. & P., Circle, Patna

Roy, R. S., Horticulturist to the Government, Sabour, Bhagalpur

Singh, Mukhtar, Dr., Agronomist, C.P.R.I., Patna

Singh, R. V.

Singh, S. M., Nagerpara Basic Training School, Bhagalpur

SINHA, M. P., Agricultural & Engineering Adviser to the Government of Bihar, Patna

SINHA, P., DR., Field Experiment Specialist, Patna

SITARAMAN, S., Superintending Engineer, Investigation & Project Circle, Patna

THAKUR, C., Pusa

Thakur, H. N., I.A.S., Deputy Development Commissioner, Bihar, Patna

F.A.O.

DEWAN, M. L., DR., Soil Technologist, F.A.O. Mission in Iran, Teheran

WHYTE, R. O., DR., Agronomist, F.A.O., Rome

T.C.M.

HAY, R. C., Professor, Head of Agricultural Engineering Department, Kharagpur, West Bengal

PARKER, F. W., DR., Chief Agriculturist, American Embassy, New Delhi

Government of India

Ministry of Food & Agriculture

BASU, J. K., DR., Director of Soil Conservation (Agriculture), New Delhi

RANGANATHAN, C. R., I.F.S., Inspector General of Forests, New Delhi

ROY, S. C., Agricultural Extension Commissioner, New Delhi

Ministry of Finance

PATEL, H. M., I.C.S., Secretary, New Delhi

Central Water & Power Commission

AHUJA, P. R., Director, C.W. & P.C., New Delhi

KRISHNAMURTY, K. V., Deputy Director, C.W. & P.C., New Delhi

Indian Agricultural Research Institute

RAYCHAUDHURI, S. P., DR., Head of the Division of Soil Science and Chemistry, New Delhi

Damodar Valley Corporation

BALAN, C., Public Relations Officer, Anderson House, Calcutta 27

BHIMAYA, C. P., Forest Officer, Hazaribagh

BHOUMICK, H. D., DR., Agricultural Chemist, Hazaribagh

GANGULI, A. B., I.C.S., Member, Anderson House, Calcutta 27

HAKIM, A. A., Executive Engineer, Hazaribagh

HULL, W. W., T.C.M. Extension Adviser, Hazaribagh

KAUL, S. N., Land Reclamation & Improvement Officer, Hazaribagh

MUKHERJEE, S., Special Land Acquision Officer, Hazaribagh

PILLAI, S. S., Director of Soil Conservation, Hazaribagh

PRASAD, S., Planning Assistant, Hazaribagh

ROY, B. B., Superintending Engineer, Hazaribagh

SAHAY, S. P., Extension Officer, Hazaribagh

SEN, P., DR., Deputy Director (Soils & Crops), Hazaribagh

SINHA, N. P., Deputy Secretary, Anderson House, Calcutta 27

SINHA, P. G., Administrative Officer, Hazaribagh

SUBRAMANIAN, V. S., Asst. Research Officer, Hazaribagh

VERMA, P. P., Member, Anderson House, Calcutta 27

Soil Conservation Trainees

DIXIT, H. K., from Madhya Pradesh

HARDAS, Y. G., from Madhya Pradesh

REDDY, D. RAGHUNATHAN, from Andhra

SAHU, B., from Orissa

SHETTY, K. P. SANJIVA, from Madras

Uttar Pradesh

GUPTA, R. S., DR., Soil Conservation Officer, Dehra Dun

KHAN, A. D., DR., Deputy Director of Soil Conservation, Lucknow

NAUTIYAL, B., Divisional Forest Officer, Lucknow

PANDEY, SHEOJI, Agricultural College, Kanpur

SETH, H. C., Senior Associate (S.C.) cum Deputy Project Extension Officer, Etawah

Bombay

GADKARY, D. A., Jt. Director of Agriculture (S.C.), Poona 1

RAMA RAO, M.S.V., P.A. to the above

SHAH, R. K., Chemistry Dept., D.D.V.M.G. Science Institute, Ahmedabad

VORA, J. C., Chemistry Dept., D.D.V.M.G. Science Institute, Ahmedabad

West Bengal

DUTT, S., Superintending Engineer, Irrigation Department, Calcutta

Himachal Pradesh

PUSHKARNATH, DR., Director of Agriculture, Simla

Bhopal

LAMBA, P. S., DR., Director of Agriculture, Bhopal

Orissa

PATRO, C., Soil Conservation Officer, Machund Hydro-electric Project

PATTNAIK, S., DR., Soil Conservation Officer, Cuttack 1

PEPSU

SINGH, BALWANT, C. F., Nabha

Nepal

SANBOLLE, B. R., REV., Godavary School, Kathmandu

APPENDIX B

LIST OF PAPERS PRESENTED AND THEIR AUTHORS

Section I — Survey & Planning for Soil Conservation

1. Land Classification in Iran, by Dr. M. L. Dewan, F.A.O. Mission in Iran, Teheran
2. Classification and Nomenclature of Indian Soils, by Dr. S. P. Raychaudhuri, Indian Agricultural Research Institute, New Delhi
3. Planning for Control of Gullies in Overall Soil Conservation Scheme, by Mr. A. A. Hakim, D.V.C., Hazaribagh

Section II — Agronomy in Soil Conservation

1. Agricultural Utilization of Lands Emerging out of Reservoirs in the Damodar Valley, by Mr. S. N. Kaul, D.V.C., Hazaribagh
2. Nitrogen Requirement of Maize in Calcareous Soils of North Bihar, by Mr. C. Thakur and Mr. C. Sharma, Central Sugarcane Research Station, Pusa, Bihar
3. Soil Fertility Investigations in Bihar and their Relation to Soil Conservation and Extension, by Dr. H. N. Mukherjee, Sabour, Bihar
4. Role of Micro-organisms in Soil Fertility and Soil Conservation under Bihar conditions, by Dr. H. N. Mukherjee and Mr. K. K. Jha, Sabour, Bihar
5. Effects of Varying Doses of Phosphoric Acid and Nitrogen on the Yield of Berseem (Trifolium Alexandrium) (Rabi-1953), by Dr. H. D. Bhaumik, D.V.C., Hazaribagh
6. Effect of Varying Doses of Phosphoric Acid and Nitrogen on the Growth of Sunhemp and Nodulation in Hazaribagh Soil (Kharif—1954), by Dr. H. D. Bhaumik, D.V.C., Hazaribagh
7. Effects of Varying Doses of Phosphoric Acid and Nitrogen with and without Amendments with Micro-nutrient Elements on the Growth of Cowpea in Hazaribagh Soil (Kharif—1954), following Berseem, by Dr. H. D. Bhaumik, D.V.C., Hazaribagh
8. Effect of Varying Doses of Phosphoric Acid, Nitrogen and Micro-nutrient Elements on the Yield of Sunhemp (Kharif—1954), by Dr. H. D. Bhaumik, D.V.C., Hazaribagh
9. Crop Response to Added Fertilizers in Cultivators' Fields — A technique for

finding out manurial requirements of Bihar Soils, Part I, Crop, Paddy, Dist. Patna, by Sri Parmeshwar Sinha, Patna

10. Response of Different Doses of Fertilizers on Cabbage, by Sri R. S. Roy and Sri B. Choudhury, Sabour, Bihar
11. Conservation of Soil Fertility in White Sugar Belt of Bihar, by Sri C. Thakur and Sri P. B. Bhattacharya, Pusa, Bihar
12. Improvemet of Soil Structure by Growing Berseem, by Sri A. K. Chaudhury, Central Sugarcane Research Station, Pusa
13. The Availability of Phosphates in the Calcareous and non-calcareous Soils of North Bihar, by Sri S. Prasad, Professor of Agricultural Chemistry, Sabour

Section III — Grassland in Soil Conservation

1. Grassland Agriculture, by Sri P. N. Ghosh and Sri M. P. Singh, Sabour
2. Improvement of Soil Fertility by grasses and legumes, by Sri S. C. Mandal, Sabour
3. Grasses and Flood Control, by Sri M. P. Singh, Sabour
4. Culture of Pennisetum and Pedicillatum in Bihar for Forage and Soil Conservation, by Sri S. N. Mukherjee and Sri B. N. Chatterji, Bihar Agricultural College

Section IV — Forestry in Soil Conservation

1. Soil Conservation Work in a Sub-catchment of the Sankha (Rajgangpur area, Sundargarh District, Orissa), by Dr. S. Pattanaik, Cuttack
2. Problems in Afforestation in Damodar Valley, by Sri C. P. Bhimaya, D.V.C., Hazaribagh
3. Further Investigations on Rajputana Desert Soils—Fertility and Mineralogical Studies, by Dr. R. S. Gupta, Soil Conservation Officer, Dehra Dun
4. Forest Means Water, by Sri Balwant Singh, Conservator of Forests, PEPSU, Nava

Section V — Soil Conservation Engineering

1. Design of Cross Drainage Works in Irrigation Distribution System for Soil and Water Conservation Benefits, by Sri A. A. Hakim, D.V.C., Hazaribagh
2. Soil Conservation in Kosi Basin, by Sri P. R. Ahuja, Superintending Engineer, Central Water & Power Commission
3. Bunding of Deep Black Soils, by Sri D. A. Gadkary, Joint Director of Agriculture, Bombay State, and Sri M. S. V. Rama Rao, P.A. to the Joint Director of Agriculture, Bombay State
4. Reclamation of Kotar Lands, by Sri D. A. Gadkary, Joint Director of Agriculture, Bombay, and Sri M. S. V. Rama Rao, P.A. to the Joint Director of Agriculture, Bombay State

Section VI — Social and Economic Aspects of Soil Conservation

1. Voluntary Consolidation of Holdings in Damodar Valley—a great Land Reforms Movement, by Sri S. Mukherjee, D.V.C., Hazaribagh
2. Role of Extension in Soil Conservation, by Sri S. P. Sahai, D.V.C., Hazaribagh

APPENDIX C

RESOLUTIONS PASSED AT THE THIRD ANNUAL SESSION OF THE SOIL CONSERVATION SOCIETY OF INDIA

1. It is suggested that a Soil Survey Committee be formed with the following terms of reference:

(i) To standardize the methods and procedures of Soil Survey and Land Capability Classification especially for soil conservation projects of the country and to develop a uniform system of quick mapping to meet the urgent demands and which will fit in

with more detailed systems to be involved later;

(ii) To devise ways and means for conducting Soil Survey and Land Classification for special purposes such as Irrigation, Land Use Planning, etc., at a speed consistent with the demand of development projects; and

(iii) In addition this Committee should also undertake exchange of information regarding:

(a) What methods and procedures of soil survey and land capability classification are being used in the various States and the agencies of the Government of India and other countries

(b) On what areas in India, soil survey and land capability classification have been carried out and what are the main findings.

The following persons are recommended to be the members of this Soil Survey Committee:

1. Dr. J. K. Basu (Convenor)
2. Dr. S. P. Rai Choudhury
3. Dr. H. N. Mukherjee
4. Dr. M. L. Dewan
5. Dr. R. V. Tamhane
6. Mr. P. R. Ahuja
7. Mr. S. Sitaraman
8. Mr. Balwant Singh

2. It is recognized that while one agronomic practice may not show encouraging results, when combined with other practices, it may enhance crop yields and help in increasing soil fertility. It is, therefore, recommended that trials should be taken up in different parts of the country, to test the combined effects of manuring with different organic manures and fertilizers, irrigation, spacing, inter-culture varieties, crop rotation, etc.

3. It is further recommended that Experimental Stations may be set up in the river valley areas to take up work on the building up of soil fertility in denuded soils in a concentrated manner, jointly between the river ralley authorities and the State Governments. The programme of work of the above Stations should also include the possibility of the introduction of a grass-legume association, in rotation with cultivated crops, for building up soil fertility.

4. Experience both in this country and abroad shows that in most cases the first and the cheapest step is to re-establish natural vegetation on the eroded sites. The closure of the areas to grazing and browsing is generally sufficient to bring in grasses, herbs and shrubs which by providing a mantle of vegetation will check further erosion and set in train the long process of rehabilitation and restoration of soil fertility. This process can be aided at the appropriate stages, if necessary, by sowing and planting of selected species of plants and by engineering works. The Society, therefore, recommends that all State Governments should take steps to close effectively to grazing and browsing areas which have been severely eroded or are in process of erosion, by using wire fencing if necessary, in areas threatened with erosion, to regulate cattle grazing by application of rotational closures and limitation of numbers.

This Society trusts that the Government of India will give adequate financial assistance to State Governments to enable them to give effect to the resolution.

5. The Soil Conservation Society of India at its third annual session considered the role of forestry and afforestation in relation to soil conservation. It recognized the importance of afforestation techniques with a view not only to rehabilitating and protecting eroded land but also to augmenting local wood supply so as to enable the use of farmyard manure for building up soil fertility. The problem of afforestation presents various difficulties in different tracts and under different degrees of erosion. A great deal of experience has been gained in this work in many States — but it was considered that further research should be undertaken in this difficult field of forestry, wherever necessary. The Society, therefore, recommends:

(i) That the Central Soil Conservation Board should compile existing information on the costs and techniques of afforestation of bare and eroded lands and publish it at an early date.

(ii) It further recommends that interested State Governments should undertake a programme of research in afforestation of various types of eroded

lands with a view to establishing the best and cheapest techniques. The Society, would, however, strongly, urge that the work of afforestation of eroded land should be pursued with vigour on the basis of existing information and should not be held up pending the completion of the proposed research programme. This Socienty trusts that the Government of India will give adequate financial assistance to State Governments to enable them to give effect to the resolution.

(iii) The Society further recommends that the Union and State Governments should sponsor a State-wide scheme of raising village plantations on compact blocks of available land with a view to increasing local wood supply and diverting farmyard manure to the fields.

(iv) The Society urges the Central Soil Conservation Board to make arrangements for the measurement collection and publication of Hydrological data relating to forests and grasslands.

6. In view of the interest taken by members in soil conservation engineering, articles with complete data and plans on soil conservation engineering works in the various river valley projects be invited for publication in the Society's Journal.

7. That the attention of the various Governments be drawn to the danger of leaving side slopes of embankments, cutting pits, etc., without any protection of a vegetable cover and to provide in their estimates for reseeding or protecting them to prevent soil erosion.

8. The Society resolves at its Third Annual General Meeting to place on record its deep sense of gratitude to the Government of Bihar for having granted a sum of Rs. 1,000 to the Society for holding its Third Annual Session at Patna.

9. The Society thanks the organizing Secretary of this session, Sri H. N. Thakur, I.A.S., for his valuable services in organizing this Third Annual Session at Patna.

10. The Society also thanks the Governor of Bihar, a Patron of the Society, for having kindly allowed the Society to hold its Inaugural Session at the Raj Bhawan.

11. The Society also thanks the Government of Bihar in allowing the use of the Secretariate Conference Room for holding the sectional meetings and the Plenary Session of the Society.

12. The Society is also thankful to the officers and staff of the office of the Development Commissioner, Bihar, for the pains they took to make the function a success.

ADDRESS OF DR. PUNJABRAO DESHMUKH, MINISTER FOR AGRICULTURE, GOVERNMENT OF INDIA

(*Continued from page* 51)

information that will enable them to educate themselves on every phase of soil and water conservation adapted to their interests. Your Society must take the challenge of soil erosion and must work out ways and means of fighting this menace. Evolution of scientific methods of soil conservation must be based on ever-increasing knowledge gained through your researches in different fields of soil conservation practices. I earnestly hope that out of your deliberations and efforts newer lights will be thrown on the subject for a solution of this mighty problem.

I may in conclusion also draw your attention to the discussion of some aspects of these problems at the recently concluded session of the Fourth World Forestry Conference. The valuable contribution that this Congress has made in this field alone would, in my view, justify the calling of this Congress in India, which is the first time it has been held outside Europe.

List of New Members of the Soil Conservation Society of India

BANERJEE, S. M., Financial Adviser, D.V.C., Calcutta

BASHEER, M. A., Soil Conservation Asst., Anantpur, Andhra

BASERGEKAR, U. K., Agricultural Officer, Sub-Divisional Soil Conservation Officer, Poona

BADAMI, G. B., Divisional Soil Conservation Officer, Bijapur

BIRADAR, S. K., Sub-Divisional Soil Conservation Officer, Bagalkot, Bombay

DESAI K. S., Sub-Divisional Soil Conservation Officer, Mehsane, Bombay

DHEKNE, D. K., Sub-Divisional Soil Conservation Officer, Dhulia, Dist. West Khandesh

DIXIT, H. K., Agricultural Asst., Hoshangabad, M.P.

HARDAS, Y. G., Mechanical Asst., Hoshangabad, M.P.

JHA, V., Deputy Commissioner, Manbhum, Bihar

JOSHI, Y. A., Agricultural Officer, Poona 2

JOSHI, R. G., Agricultural Officer, Sholapur

*KAITH, D. C., Director of Soil Conservation (Forestry), Government of India, New Delhi

KAVALUR, V. R., Sub-Divisional Soil Conservation Officer, Dist. Belgaon, Sholapur

KALKOTI, K. C., Divisional Soil Conservation Officer, Anand Mohal, Bijapur

KELKAR, D. G., DR., Divisional Soil Conservation Officer, Baroda

KHOSLA, A. N., I.S.E., Vice-Chancellor, Roorkee University, Roorkee, U.P.

MISHRA, M. D., Asst. Professor of Agriculture, Agriculture College, Kanpur

MEHTA, D., I.S.E., C.E., Irrigation, Bihar, Patna

MCNEE, P., Director, Drainage & Irrigation, Malaya, Kuala Lumpur

MUKHERJEE, B. S., I.A.S., Deputy Commissioner, Palamau, Bihar

MAYDEV, S. V., C/o Director of Agriculture, Poona

NEWRGAONKAR, Y. S., Agriculture Officer, Dist. Ahmadnagar

PHUKAN, L. N., Agricultural Chemist, P.O. Jorhat, Assam

PRASAD, S. S., Asst. Agricultural Engineer, Kanke, Ranchi

PHADHKE, A. B., C/o Director of Agriculture, Poona

PATEL, S. P., Principal, Soil Conservation Institute, Baroda

PATEL, G. V., Raopura, Baroda

PRASAD, K., Asst. Director of Agriculture, P.O. Netarhat, Ranchi

PRASAD, S., Planning Assistant, D.V.C., Hazaribagh

PUNDALIK, P. J., Agricultural Officer, P.O. Ghodnad, Poona

PURANDHARE, G. T., Agricultural Officer, Ahmadnagar

RAMCHANDRAM, V., C/o District Magistrate, Patna, Bihar

REDDY, D. R. Asst., Agriculture Engineer, Anantpur, Andhra

RESIDENT ENGINEER, Gal Oya Development Board, Amparai, Ceylon

RAO, M. S. V. RAMA, P.A. to the Joint Director of Agriculture, Poona 1

SWAMIKAN LEO, Agricultural College & Research Institute, Coimbatore

SHETTY, K. P. S., Agriculture Engineering Supervisor, Saidapet, Madras

SINGH, M. S., Soil Conservation Asst., Anantpur, Andhra

SUBRAMANIAN, M., Agriculture College & Research Institute, Coimbatore

SAHU, B., Forest Ranger, Sambalpur, Orissa

SINGH, H. M., Agricultural Inspector, P.O. Netarhat, Ranchi

* Life member

SHIRNAME, T. G., DR., Director of Agriculture, Bombay, Poona 1

SHETTAR, M. G., Sub-Divisional Soil Conservation Officer, Miraj, Bijapur

SATPUTE, R. V., Sub-Divisional Soil Conservation Officer, Poona

SHAIK, BADAN, L. J., Agriculture Assistant, P.O. Palaodav, Poona

SINGH, HARI, Conservator of Forests, Nasik, Bombay

*VERMA, P. P., Member, D.V.C., Anderson House, Alipore, Calcutta 27

WADEKAR, B.S., Agricultural Officer, Sholapur

YAWAGAL, J. G., Sub-Divisional Soil Conservation Officer, Bijapur, Bombay

ZAMBRE, D. V., Agricultural Officer, North Satara

ZOPAY, E. L., Sub-Divisional Soil Conservation Officer, Sholapur

* Life member

Book Review

INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT, Vol. IV, No. 10 — Hirakud Project Number — edited by K. K. Sinha, published from 6 Waterloo Street, Calcutta 1, pp. 82 plus 30 pages of maps and sketches. Price Rs. 5.

THIS IS A SPECIAL NUMBER OF THE WELL known Indian technical journal dealing with India's longest dam. The contributions are from persons closely connected with the project and as such they include the most authoritative data about the dam and its construction features yet made available to the public. All the contributions are profusely illustrated with maps, drawings and sketches which enhance the technical value of the contributions immensely.

The main contributions are by Sri M. S. Thirumale Iyenger, Chief Engineer of the project dealing with the project as a whole, Sri A. R. Challani dealing with the main dam, Sri N. Dharmarajan on the power system, Sri K. P. Pillai and Dr. K. C. Thomas on the canal system, and Sri Raghavachari on the project organization. The number is printed throughout on art paper.

It is gratifying to note that this project is after all making satisfactory progress after a hesitant start and we are also glad to note that its over head charges are low in comparison with other similar projects.

This number is a handbook for all engineers, legislators, administrators and economists for ready reference regarding all aspects of the project. A.A.H.

Editorial

IRRIGATION and flood prevention feature largely in river valley schemes in India besides hydro-electric power generation and sometimes navigation. These schemes are largely governed by the hydrology of an area and hence a river valley constitutes a logical territory for such integrated multiple purpose development. In areas of seasonal rainfall and runoff, as is the case with most river valleys in India, most of the schemes constituting the development benefit by reduction of the peaks of runoff of water and the retention of the silt. The nearer the approach to perennial clear streams with uniform flow, the greater and more economical the utilization of the waters. A survey of the entire area determining the capabilities of the soils as well as the present uses of the different areas of land and the planning of a better distribution in order to conserve the maximum amount of moisture and soil by all known methods should, therefore, be the first approach to river valley development. Afforestation on the steeper and more erodible slopes is one of the most economical methods and on great gradients and poor soils often the only practical way.

In practice, the big engineering projects in the lower reaches of the river and tributaries constitute the first step. They are more spectacular, can be designed and executed quicker, can provide flood protection and irrigation adequately to areas below them at a cost; and in any case a few dams are essential for generation of hydro-electric power. Their economics is determined on designs of engineering structures allowing for existing hydrological patterns. With the result that, once the major engineering scheme is approved as adequately economical, there is hesitancy and reluctance in improving the economics by financing upstream engineering through afforestation and better agricultural practices even though such engineering can reduce the runoff of silt and water significantly. Such a view is illogical. Suitable natural sites for large storages are often few; elimination of some of these on the grounds of economics based on existing hydrological patterns without taking into account all methods of soil and water conservation that may completely alter the picture is not in the country's interest. Larger works are based on an approximate life of 100 years or so. Even where an actual site falls below this, efficient upstream conservation can reduce the silt and give it a full life. Efficient soil and water conservation in the catchment can render existing works significantly more economical by reducing the flood margins now allowed rightly on conservative lines by flattening the peaks of runoff. By reducing silt they can also render a smaller dead storage necessary, thus increasing the total live storage for the same capital cost of the structure.

The economics of such important and large scale engineering schemes, designed and constructed on existing hydrological patterns, indicate that large sums of money can be released for water and soil conservation practices upstream. An examination of the Damodar Valley Project's first phase of 4 dams indicated that against a total capital of 46 crores on the dams, even assuming a very conservative benefit of a release of 20 per cent of the flood reserve to live storage would release Rs. 2·8 crores from the allocation to flood protection. The extra hydro-electric energy generated by release of more capacity for live storage would produce an extra revenue of Rs. 40

*This paper was presented by the EDITOR to the "Fourth World Forestry Congress", 1954, at Dehra Dun and reproduced with acknowledgement to them.

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lacs per annum. Silt prevention could easily double the period in which the dead storage would fill and this would release Rs. 5 lacs annually from the contribution to the depreciation fund. The total scheme of soil and water conservation in the entire valley costs a good deal less than this. Thus, where capital assets concerned are large, as in river valley schemes, and the intensity of financial operation is high, a careful assessment of the economics of various practices to secure the temporary retention and discharge of steady supply of water over a long period would release sufficient funds for such practices to be taken up at a level where they will more than pay for themselves. This is the important distinction in problems of forestry with the main objective of soil and water conservation in river valleys as compared with those in areas outside. Such assessments are confined to the benefits accruing to the larger engineering projects below and omit the considerable though somewhat imponderable advantages of better moisture and better soil conditions, a higher level of ground-water level in the upper valley and the enormous benefit of perennial streams to all the villages in their course.

After a lapse of 60 years the Government of India in their revised forest policy have increased the emphasis on the forests as a factor in securing correct land use and the retention of soil and water in the upper reaches of river valleys and river banks as well as stopping the advance of the desert. Forests primarily designed for these purposes are classified as "protection" forests. While the previous forest policy of 1894 stressed the importance of local interests in fuel, fodder and grazing in neighbouring areas over the revenue aspect of forest management and the stronger claims of cultivation due to the pressure of population on land, the recent policy has found it necessary to review the point. "While, therefore, the needs of the local population must be met to a reasonable extent, national interests should not be sacrificed because they are not directly discernible, nor should be the rights and interests of the future generations be subordinated to the improvidence of the present generation." On the question of competition of agriculture with forestry, it says "the old policy, which envisaged the relinquishment subject to certain safeguards honoured only in their breach, of even valuable forest land for permanent cultivation, has resulted in general deterioration of physical conditions to the detriment of national interest and must, therefore, be given up. The role of forests in the national economy, both protective and productive, entitles forests to lay claim to an adequate share of the land." The policy goes on to say in regard to the protection forests that "an immediate and speedy programme for reconditioning of the mountainous regions, river valleys and coastal lands by establishing protective forests over large areas, and preserving existing ones. The primary object of management of such forests should be to utilize in full their protective influence on the soil, the water regime, and the physical and climatic factors of the locality; and the interest to be thus protected should far outweigh those which it may be necessary to restrict."

The effect of forests on climate is a subject on which there are misconceptions. A good forest implies an effective canopy of leaves and a continuous ground cover of dry leaves and humus over soil in good condition. The canopy takes the impact of the rain and intercepts a portion of it. The wetting of the leaves, the branches and trunks of the trees encourages evaporation and the total amount intercepted before it reaches the ground can be a considerable part of the total precipitation over the forest. The temperature varies less inside the forest and the interception of direct solar radiation contributes towards this. A higher humidity prevails. The soil covered by litter and humus and shaded by the trees is cooler in summer and warmer in winter. Loss of soil moisture by evaporation is reduced both by the ground cover as well as the tree-tops to nearly a third or half the evaporation from exposed soils outside the forests. Such soil protected by the litter is estimated to hold nearly twice its weight of water and the standing litter of decomposing matter makes for continuous percolation and better soil conditions. Wind velocity is lost inside a forest reducing evaporation and wind erosion. While it is doubtful whether forests do increase the total amount of precipitation over themselves as well as the neighbouring areas, they certainly help in conserving the rainfall, noticeably reduce floods and increase continuous flow in streams flowing

out of them. These are results of observations mostly in other countries and as such are only of general application. It is the quantitative determination of the cost and efficiency of each factor in retaining the water and soil, and spreading out the flow of water that falls in seasonal rains that will largely govern the economics of the type of forests cover that should be created.

While, obviously, soils that are too poor to support agriculture have to be retired to forests and by and large areas capable of reclamation for crops have been so reclaimed, it is not always so. Opening of communication, provision of irrigation or rise in foodgrain prices as well as the ever increasing pressure of population on land contribute to changes in land use and forests on good soils are liable to invasion as the environment changes. The present distribution of forests, no doubt, based on ecological factors may not always be the best. While the uppermost reaches with steep gradients and eroded soils can without difficulty be included in the areas to be afforested, where they are not already so included, there are many vulnerable areas of steep slopes, escarpments that catch heavy rain, or locally very erodible soils that need to be put under forests. A land capability survey accompanied by mapping of rain intensities would, therefore, seem to be the first step. Modern methods of indicating gradients and slopes could be adopted with advantage. These would indicate what fresh areas should go under forest and, where there is pressure for land, which areas now under forest could be released for agriculture if it is necessary.

One of the most serious limitations in conservation planning is the absence of most relevant data particularly of quantitative significance relating to rainfall and runoff of water and silt. It is unfortunate that this aspect has received so little attention in the past. Selection of approximately equal catchments, measurements of intensities of storms and total rainfall and water and soil runoff with automatic recording instruments that could be attended to at intervals of two weeks or a month, so that one observer can be in charge of several such stations often difficult of access and which are to be visited in the difficult monsoon period, are obvious and urgent needs. Selection of several such areas with different types of forests and also mixed areas of forests, wastelands, upland cultivation and terraced paddy fields should in the course of a few years afford data of considerable value in determining the comparative soil and water losses under different types of land use. Soil and water conservation practices of different types and intensities in these areas with different types of cover should help in determining what practices are best for what areas and slopes and their economics. Systematic statistical examination by decades of rainfall and storm intensities, annual and monthly temperature variations (mean and extreme) and variations of wind velocity and humidity in certain stations, e.g. Ranchi where it is known that deforestation on an extensive scale has happened in the last three decades or so — such figures as are available — would indicate clearly the effect of forest on physical characteristics in the neighbourhood. These are lines of activity that cost little but require careful set-up, enthusiastic and correct observation and unprejudiced analysis. The case for immediate expansion on these lines is very strong indeed.

The growing of fuel, fodder, fruit and timber trees is a matter of economic interest to agriculturists even in non-forest areas. Effective wind-belts significantly contribute to reduction of water losses by evaporation. Methods of germination and speed of growth of trees likely to be of use in different localities could well be ascertained in small areas inside the numerous agricultural farms in different parts of State at little cost. Forest nurseries are few and confined to the thickly forested areas. In this as in many other problems in this country, local data are extremely inadequate. Research and co-ordination with agriculture has not been conspicuous whatever may have been the reasons. Specific recommendations of species for various purposes in the different soil and climatic regions are wanted. Efficient shelter-belts, woodlands and tree plantations reduce the pressure on forest and help ultimately in better management of protection forests.

The practical performance of existing forests in effecting soil and water conservation is extremely disappointing. In assessing the short-comings and suggesting remedies the limitations of the writer, who is

by profession an administrator and not a forester and whose acquaintance with forestry problems is largely limited to areas of Bihar and Orissa, should be borne in mind. The stress is on adequate programming as the policy covers satisfactorily most points. It is, however, possible that the problems discussed and the solution suggested may be of value to other areas as well. One often finds the worst cases of erosion inside the forest. Extensive cutting, mostly of an unauthorized variety, widespread burning of the ground cover on 60 to 70 per cent of the entire area each year and uncontrolled grazing by cattle, buffaloes, sheep and goats prevail. Much of these areas constituted private forests of landlords. High price of timber during the war, the threat of taking over the management of these forests by Government, extension of communication and motor transport, a policy of enlargement of rights of tenants as against the landlords preceding the taking over of all landlords' estates by Government have all contributed to much destruction. Much of the sal areas are of 5-6 years' growth of coppice, the soils are exposed, deeply eroded, and completely devoid of humus or litter. If these forests are to be restored to their proper function of "protection" forests and public support is to be gained by the performance of these forests a rational analysis of the factors leading to the misuse of the forests is necessary. Treatment of symptoms however enthusiastically undertaken will not cure the disease. If the basic approach is determined research, programmes and execution could follow automatically.

Extensive cutting of trees and saplings for fuel, housebuilding, timber and fencing poles by villagers of the neighbouring area for their consumption is one of the factors militating against the efficiency of the forest in providing a good canopy. There is also similar cutting for sale by local residents on head-loads. A third variety is illegal exploitation on the commercial scale by businessmen. The last one can certainly be stopped without any difficulty. Compulsory treatment of all housebuilding and other timber that lengthens its useful life by five times or more is equivalent in the long run to increasing the area of the forests that provide such timber that many times. This aspect requires more consideration than it has received so far. As long as there is a genuine need for fuel, housebuilding timber and fencing poles for local consumption, it will not be possible to stop it by legislation or executive action. Under the local laws, residents of villages have been recorded as having rights as against the landlords to cut timber in specified forests for their consumption. A feudal relation persisted by which tenants excercised their right in proportion to their strength and influence as against the landlords. The latter as owner had the profit motive and often leased out forests or allowed over-grazing for revenue. The forests generally deteriorated except in inaccessible areas or where the population pressure was small. With the taking over of management, all the area recorded as forests have been declared protected, but much of it has no standing timber or even shrubs. Any *ad hoc* working plan limits the quantity and the location of the timber to be exploited to which the villagers are not yet used. The total amount of timber is inadequate as against the present demand (which perhaps is higher than before thanks to a sense of public ownership in a democracy with adult suffrage, increasing knowledge of the rights and privileges and some other factors). As with controls of other commodities, legislative and executive enforcement of limitation on consumption in areas far from effective supervision and guarded by low-paid personnel is bound to fail. The obvious but long-term remedy is a programme of positive afforestation not only of the blank spaces in the protected areas but of other wastelands with increasing emphasis on areas that are particularly short of supplies of timber, fuel, etc. In forests newly grown, by and large, cutting and grazing rights will not prevail and they have a chance to get soon into good condition. Meanwhile, scope exists for a survey of all the areas declared protected and of throwing open some areas which need not necessarily have forest cover from the point of view of silt and water runoff to meet immediate demands. Afforestation followed by an efficient scheme of exploitation by coupes constitutes an excellent demonstration of accelerated timber growth under protection even though it is a slow process. A logical attempt to restore the appropriate share of land to forest cover followed up with

schemes of afforestation on an adequate scale, even though it may be much in excess of what was thought as possible in the pre-planned period, is a crying need. In the dominantly agricultural First Five Year Plan, the provision under forestry in Part 'A' States constitutes about 1 per cent of the total. There seems to be scope for a review of targets and programming on a level which has closer relation to the ultimate target laid down in the forest policy.

It is obviously impossible also to cut across economic traditions at once. A large number of people have as their main profession the extraction and sale of forest produce and fuel on headloads. This profession is an important cushion to the vicissitude of rural agricultural life in various areas and any attempt to restrict it suddenly will be unsuccessful and only result in unpleasantness. The long-term remedy lies in the establishment of higher rural standard of living and opportunities which will render this profession unattractive. There seems to be no specific short-term remedy.

The cutting of saplings, particularly of sal of diameter varying from 1 to 3 in. to provide a solid wall of fencing for backyards of houses which vary in area from about 200 to 4,000 sq. ft. is a widely prevalent practice recognized by custom. Crops like maize and vegetable are grown in the enclosed fences during the monsoons and the entire fences are burnt up as fuel afterwards. Counting the potential value of timber that is cut off in its infancy, this is perhaps one of the most expensive fences in the world. Issue of free and subsidized wire fences as a permanent measure has not been tried. There may be snags, but far more revolutionary ideas like artificial insemination of cattle or the Japanese Method of Paddy Cultivation have found surprising acceptance in extension experiments on other fronts. Even a few such fences in each village may work, and if they do, the saving in forest wealth would be enormous. In the new set-up of planned development, there is no reason why an experiment of this kind should not be tried on a large scale.

Destruction of game and the disturbance of biological equilibrium of the forests naturally goes with unrestrained access for all people on all fronts, even though poaching is confined largely to professional *shikaris* working on their own or often under the organized supervision of a commercial dealer in illicit meat of wild game. Profits are high with its usual consequences. Apart from tightening up shooting laws, sanctuaries and national parks seem to be the only answer.

The forest litter and the humus and the soil below constitute a most important factor in water and soil conservation and the systematic annual destruction of the litter by fire is possibly the single greatest factor mitigating against the efficiency of the protection forest. Unlimited grazing rights followed by indiscriminate grazing push up the demand for fodder. The burning of dry leaves exposes the soil and helps more grass to come up. In the search for collection for *Mahua* flowers (*Bassia latifolia*), the litter under each *Mahua* tree is destroyed by fire to create a clean surface from which the falling flowers can be picked. There is also the widespread feeling that ashes of dry leaves when burnt will go down the gullies into the terraced paddy fields and add to the fertility of those fields — a somewhat expensive manure if all costs are taken into consideration. Here again, far too many basic economic factos are involved for quick remedies to prevail. The problem of numerous inefficient cattle population is the basic one. A poor cow maintained mainly for the sake of its poor progeny of bullocks and fuel and farmyard manure production when penned in the village at night and grazed free in public forests often shows a better balance-sheet than a good cow, stall-fed and properly managed particularly where milk is not consumed or sold. Removal of uneconomic cattle, better breeds and feeding and management and better agricultural practices including consolidation of holdings are obviously necessary and largely fall outside the forester's jurisdiction. The fact that rotational grazing produces more fodder from the same area could well be used. In fact the forest policy stresses the need for "rotational grazing, the benefits of which should be explained and demonstrated to the villagers as continuous grazing destroys the better grasses. Free and indiscriminate forest grazing leads to a large cattle population of poor quality and thus a grazing fee helps directly in improving the quality of cattle." The policy discourages grazing in protection forests. Reservation of adequate, not very erodible and

poorly forested areas, their fencing by wire or ditching and rotational grazing by dividing into 3 or 4 areas should work. A demonstration of mere fencing with its heavy growth of better grasses by itself should have considerable value. In fact, even from the point of view of soil erosion, a good stand of grass well protected from indiscriminate grazing as well as fire can help a great deal. It can very usefully precede afforestation schemes and bring up the soil quality for afforestation.

An inexplicable gap in recruitment and training of Forest Officers for the highest executive cadres for a period of 7 years in the forties is exercising the maximum damage to available technical capacity now, at a time when planned development with some relation to ultimate targets is becoming possible. The damage cannot be remedied wholly, but the earliest possible steps are obviously necessary for increasing training facilities to make up for these gaps as well as to meet the future demands of an adequate staff. The other temporary remedy is to retain such superannuated staff as are fit enough to still discharge their duties. Accelerated promotion to responsible executive posts with inadequate training must necessarily reduce supervisory efficiency. A tribute must, however, be paid to the persistent and exemplary love of the trees among men of Forest Department notwithstanding the incredible strain of an inadequate and junior staff with expanding programme and stresses of a new democracy imbued more with a sense of privileges rather than of responsibilities so far.

Research and the gathering of data, surveys and the planning of specific programmes, recruitment and training of staff and the " prompt, positive and persistent " execution of programmes are important steps in the creation and management of efficient protection forests in river valleys. If they can be demonstrated to be economical, financing should not be difficult. But the spread of knowledge of the value of such forests among the people, the administration, legislators and the persons who constitute Government and above all the new generation at school, is essential. Forests touch the interest of all — directly those living nearby, less directly the people in towns who use fuel or timber or coal or even hydro-electric power. Forestry is also a long-term art and suffers the handicap of all those who try to provide for the future, to some extent as against the present. And the men of the forest are often shy. All the arts and aids known to the fast developing extension technique of the country should be used for the spread of knowledge of forests. Text-books for schools, talking points for social educators, cinema films, radio talks have all to be harnessed. In the ultimate analysis, it is not technological efficiency alone but the understanding acceptance all round of the policies and programmes that ensures success.

Classification and Nomenclature of Indian Soils

by S. P. RAYCHAUDHURI

WITH the attainment of an independent status as a science, soil science drew serious attention of all workers in the line for proper classification of a large variety of soils, describing and showing their distribution on a map with the ultimate object of assessing their potentialities in land use. As a first step to this, categories of classifications were worked out. The Russian soil scientists were the first to define soils on the basis of natural forces that caused soil differences and established the

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higher categories of classification to picture the Great Soil Groups. Defining soils in terms of their profile characteristics the American soil scientists named the lowest category of classification, e.g. the " type ". Soil workers of different countries established intermediate categories to inter-relate the great soil groups and types although they often differ in terminology and sometimes in meaning too.

The recognition of soil types in an area is the chief object of soil survey to which all agronomic data can be conveniently related and from which experimental results to other identical types can be extended. Such differences would appear inevitable due to puzzling patterns in soil distribution and the varied aims and objects of different surveys.

It has been recognized that soil survey should have an important place in agricultural planning. The purpose of soil survey is to have a knowledge of the soil resources of the area and to determine the qualities and the locations of different kinds of soils in order to put this knowledge to practical utility. Ultimately, accurate soil maps should be prepared showing the locations of different kinds of soils in an area, with sufficient details of categorical definition to indicate the differences significant to man in using the land for the growth of crops. Thus the purpose of soil survey is admittedly utilitarian, but its importance to pedologists consists in an elucidation of the regional relationships of soils and the influence of climate, parent material and topography on soil genesis.

The principles and techniques of soil survey depend upon the purpose for which it is undertaken. The history of soil survey in India may be traced back to the early days when the system of soil classification for the purpose of land assessment for revenue was undertaken. This was mainly based on the suitability of soils for certain crops under local conditions even though the systems followed in different parts of the country were somewhat different. The factors mainly taken into consideration for such classifications were texture, colour, availability of water, level of the land and yield of crops. These systems were not based on scientific principles but were of older practical utility. Later on in some parts of the country, e.g. the Punjab where agriculture depends mainly on irrigation it was found necessary to introduce additional soil factors, e.g. *p*H, soluble salts, silt and clay contents of soils in order to assess the land for the purpose of revenue.

A scientific approach to the study of Indian soils and their classification was first made by Leather (1898) who distinguished four major groups of soils, e.g. (1) the Indo-Gangetic alluvium; (2) the black cotton or *regur* soils; (3) the red soils lying on metamorphic rocks; and (4) the lateritic soils. The relation between the broad soil zones of the country and the basic geological foundations had been discussed by Wadia *et al.* (1935). A soil map showing the boundaries between the different general types of soils was given by them (loc. cit) pointing out the fact that the approximate boundaries of these soil groups are nearly co-terminous with the boundaries of the geological outcrops. Champion (1936) presented a map showing distribution of fifteen climatic types. Not much work has, however, been done correlating climate or vegetation or both with the formation of soil. Basu (1937) pointed out that the soils of India show certain differences in different zones divided on the basis of Lang's factor. Viswanath and Ukil (1944) prepared a soil map of India portraying the different climatic types on the basis of the N.S. Quotient. Based on comparative studies on 49 selected soil profiles of India Viswanath and co-worker (1944) adopted colour and texture as units of classification and these were in turn treated on a background of four major climatic zones, viz. arid, semi-arid, humid and per-humid.

An integrated study of the effect of climate, vegetation and topography on the formation of the soil has not, however, been done so far. A soil map of the type that exists for the U.S. is not available for India. The first attempt to correlate the data was made by Scholasky (1928) who published a soil map of India on the Russian system.

A considerable number of soil survey has been carried out in the country for certain specific purposes, a few of which may be mentioned here, e.g. (1) soil survey in connection with irrigation projects in Madras, Mysore, Hyderabad, Bombay and the Punjab (I); and (2) fertility survey with particular reference to N, P and K, i.e. nutrient status, the lime contents and the mechanical composition of the surface and sub-soils in almost all the States and in regions growing tea, coffee, chinchona, etc., under the

auspices of certain associations. Soil erosion survey has been carried out in the Bombay State. Thus the data are voluminous but fragmentary being devoid of a common objective.

Genetical soil studies and classification of soils based on morphology, physical, chemical and mineralogical compositions are of comparatively recent development in the country. Sen and Deb (1941) and Raychaudhuri and co-workers (1941, 1942 and 1944) studied the lateritic and red, soils of India and divided them into five categories, e.g. (1) laterites; (2) lateritic soils; (3) red earth; (4) red loam; and (5) red, sandy soil on the basis of variations in chemical, physical and mineralogical composition down the profile. Mukherjee and Das (1940) in their studies of Kumaon Hill soils at Chaubatia in Uttar Pradesh found four major genetic types, e.g. forest soils, podsols, red loams and wiesenboden. Agarwal and Mukherjee (1951) distinguished three major soil types depending mostly on the degree of calcium leaching down the profile in their soil survey of the Gangetic alluvium of the Gorakhpur district of Uttar Pradesh. Basu and Sirur (1938) in their survey of the canal zones of Bombay-Deccan classified the soils into twelve types as follows:

6. Saline and alkali soils.
7. Desert soils.
8. Peaty and marshy soils.

Important fundamental studies on soils have been carried out by Mukherjee and his associates (1937, 1942 & 1945) who brought to light a number of features common to the colloidal constituents of soils of different origin and type. They also revealed characteristic variations between clays obtained from different soils, and a system of differentiations of clays has been worked out based on such variations.

Soil studies with particular reference to survey have not been meagre but were not done under uniform and standardized methods adaptable to the country, and in the system of classification there is a great lack of co-ordination and understanding on the genetic relationship of various soils so that the results of one farm cannot be applied to another with a degree of certainty. However, a soil map of India was prepared under the All-India Soil Survey Scheme financed by the Indian Council of Agricultural Research after collating all the available data (1953). A revised soil map of India has recently been published (1954) on the basis of further information collected since then.

TABLE 1

Great soil group	Family associates	Series and types	Phase
Immature tropical	1. Oromorphic (high level shallow soils)	G, H & F	Mature and immature (eroded)
Tschernosem	2. Phytomorphic (low level shallow soils)	E, A, D, K & L	
—	3. Hydromorphic, Halomorphic (deep soils, low lying)	C, I, B & J	Normal saline

From the brief account of different soil studies given above, it is possible to recognize the following broad soil groups in India although all these soil groups have not been studied with equal emphasis:

1. Red soils which may be classified as red earth, red loam, yellow earths, etc.
2. Laterite and lateritic soils.
3. Black soils of varying types, including the black cotton soil or *regur*.
4. Alluvial soils, although ill-defined and elaborate study will help proper classification.
5. Forest and hill soils.

Unlike in the temperate countries, soil survey and soil classification in the tropical and sub-tropical countries have not made much progress due to natural disabilities. In recent times, however, increased attention is being paid on this problem. A useful discussion was held at the first Commonwealth Conference on tropical and subtropical soils at Harpenden, England, in June 1948 in which all soil experts opined that adoption of a common basis of classification of tropical soils was difficult in absence of detailed and authoritative information on morphological, physical, chemical

and mineralogical properties of these soils. Referring to India it was pointed out that the black cotton soil or '*regur*', which though superficially has some resemblence to the Tschernosem, differs from it in many more fundamental aspects. Similar soils have been found in other tropical countries, such as Kenya, South Africa, in parts of South-east Asia and Australia. More stress is now being laid on soil survey in the country and under the Technical Co-operation Mission soil survey is being carried out in 40 centres throughout India on soil-climate basis. Most of these centres fall under the Community Project areas or National Extension Blocks. These forty centres have been divided into six zones, namely Coimbatore, Poona, Nagpur, Sabour, Kanpur and Delhi. The main objective of this soil survey work is to study the soils of the above areas and find out representative profiles in the different regions and correlate them. The actual work was started in November 1953. Uptil now (Dec. 1954) work has been completed in six centres. In another five centres the work is in progress. Taking a view of the total work done so far in these eleven centres, 2,850 sq. miles covering 1,250 villages have been surveyed. In these areas about 370 profiles have been examined, out of which 41 have been sampled for analytical work. Moreover, 31 monoliths up to 6 ft. depth have been collected. Along with the profiles which are sampled, certain amount of associated samples (only surface samples) are also collected round about the profile. So far the total number of associated soil samples collected amounts to 1,550. Over and above this work agronomic and socio-economic information have also been collected from almost all the villages surveyed so far. A more systematic and detailed all-India soil survey on soil region basis has been planned. This survey will be characterized by detailed field study from the point of view of soil classification and soil correlation and general agricultural development. This detailed soil survey will lead to preparation of comprehensive maps portraying the individual soils and their suitability for crop production and management. In this survey the *catena* concept will also prevail where two broad groups of soil exist together. The Damodar Valley Corporation has taken up a plan of survey with the purpose of soil conservation and land reclamation and cultivation of paddy and pasture, and growing of forests.

In conclusion, it need be said that a system of soil classification for general adoption in the country has to be found. There is a tendency amongst the soil workers in the country to classify the soils according to the recognized groups of soils in Europe and U.S.A. with which the soil in question may show some similarities in colour, texture, etc., though significant differences in other important properties from their European and American prototypes do exist. The units of classification and nomenclature are not the same and there is an immediate need for the uniform method of soil survey and nomenclature in soil classification work in different parts of India and to co-ordinate the work on an all-India basis.

Soil classification based on morphological features by Basu in the Bombay State and by Mukherjee in Uttar Pradesh have been dealt with earlier. Soil survey for irrigation purposes aim at determining water relation of soils and classify them into those suited and unsuited for irrigation. It has been felt that pre-irrigational soil survey is very important and equal emphasis has also been laid on post-irrigational soil survey, and hence in many parts of the country under certain river valley projects such surveys have been carried out. The Irrigation Department of the Bombay State surveyed the soil and sub-soil of the Deccan canal tracts in order to find out the suitability of the soil for irrigation where more emphasis was attached to the depth of the *murum* and the nature of the sub-strata. The soils were classified in order of their suitability for irrigation on the basis of morphological features, topography, depth of *murum* and sub-strata. The Damodar Valley Corporation has surveyed large areas commanded by different reservoirs and classified the soils into different categories based on physical properties (type of soil and depth), salt distribution and permeability (taking into account any pan formation). The Irrigation and Power Research Institute, Amritsar, is also carrying on pre-irrigation survey of the project areas under Bakhra Dam in the Punjab and Chambal Hydel Project in Madhya Bharat.

Soil conservation surveys including soil erosion and land utilization for soil and water conservation planning including

recommendation for erosion control on uplands, ill-managed forests and the gullied lands which contribute most to this erosion menace thereby helping these lands to produce most and deteriorate the least, have also been attended to in some of the States. Since 1945, conservation surveys have been undertaken by the Soil Erosion Section of the Land Development Research Project of the Bombay State. The work has been carried out at various centres chosen at random in the scarcity tract of the Bombay-Deccan. From this survey it has been possible to assess the damage caused to soils by erosion and to classify the soils according to their suitability for different kinds of land use on the basis of examination of the soil, slope, rainfall, vegetation, etc. From erosion survey, the Damodar Valley Corporation grouped soils into five classes according to suitability for land use and growing of crops. The School of Economics grouped soils into classes I, II, etc., according to the income of farmers.

At the present moment land-use survey on all-India basis is a prime necessity based on physical inventories, e.g. texture of soil, depth, slope, soil reaction, salt concentration, permeability and surface conditions. This will provide us with basic data to enable preparation of land utilization plan that will avoid further misuse of land putting them to the best economic use.

Survey of India maps (1, 2 or 4 in. to a mile scale) be taken as base maps for the purpose and soil conditions as stated above featured on them in code for the whole country. For detailed survey, the cadastral maps on 16 in. to a mile or the village maps may be used. Aerial photographs on 4 in. or 6 in. to a mile scale, if available, may also be used particularly for undulating and hilly areas. As data go on accumulating from basic soil survey, the information so obtained can be superimposed on such maps ultimately resulting in maps representing different soil types with the physical, chemical, mineralogical and land-use properties.

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Crop Response to Added Fertilizers in Cultivators' Fields — A Technique for Finding out Manurial Requirements of Bihar Soils*

—by PARMESHWAR SINHA

PART I

Crop — Paddy
District — Patna

A study of the nitrogen response growth curves for clay, loam and sandy-loam soils of Patna district

Introduction

IN the State of Bihar, paddy is grown abundantly covering nearly an area of 1,391,000 acres. The soils of the State differ in many places and as such responses of fertilizers on different crops are likely to be very variable. With this end in view, it was considered necessary to investigate into the manurial requirements of this crop and other crops on the different soil types of the State.

Accordingly, the State Government in the year 1948 launched a Scheme, called Manurial Tables Scheme (now Field Experimental Service), to investigate into the problem of manurial requirements of various crops. The data represented here are the results of the investigation under this scheme on paddy crops for Patna district only.

Mukherjee[2] has given a synopsis of the working of this scheme along with salient descriptions of the broad soil types of Bihar. He has found an indication of the variations in yields of crops with the same dose of fertilizers on different soil types. His observation was based on two years' data and as such needed further confirmation before any generalization could be obtained. Also the Department of Agriculture through experiments in farms have derived conclusions (from time to time) regarding manurial requirements of the paddy crop, but they on account of their scattered nature could not receive wider applications. The large scale experiments as investigated in the Manurial Tables Scheme from year to year enable us to generalize the observations more reliably and the data presented below are the part of the programme pertaining to one area, i.e. Patna district on three distinctly different soil types expected to give clearer and detailed idea regarding yields obtained due to different treatments of nitrogen.

Experimental Layout and Results

The experiments were conducted on factorial designs[1] scattered in the randomly selected[1] cultivators' plots throughout the whole district. Although on account of non-availability of land and other complications replications were not included at the site of each experiment, yet the whole experiments in the area within the range of each soil type are supposed to be very well replicated, because the soil and climatic differences are not much.

The number of experiments conducted on the cultivators' fields, of which the yield data have been included in this study, being grouped according to soil types, are given below in Table 1.

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TABLE 1 — THE NUMBER OF EXPERIMENTS GROUPED AS PER SOIL TYPE

SOIL CLASSIFICATION	1949-52	1950-51	1951-52
Clay	13	49	52
Loam	22	65	72
Sandy-loam	6	2	29

The experiment was conducted by adopting a six-subplot technique and the total area covered by each experiment was 0·6 acre, which was further subdivided into subplots of 0·1 acre each. The manurial schedules of different treatments as adopted in the experiments done during the years 1949-50, 1950-51 and 1951-52 and included in the present study are given below in Table 2.

TABLE 2 — SCHEDULES OF MANURIAL TREATMENTS ADOPTED IN THE EXPERIMENTS OF 1949-50, 1950-51 AND 1951-52

Years	TREATMENTS 1	2	3	4	5	6
1949-50	0	20 N.	30 N.	40 N.	30 N. 37·5 P.*	30 N. 25 P.†
1950-51	0	40 N.	40 N. 40 P.‡	40 N. 40 P.	40 N. 8 P.§	40 N. 25 P.§
1951-52	0	40 N.	60 N.	40 N. 40 P.	60 N. 40 P.	60 N. 40 P.¶

*=N. and P_2O_5 were exclusively applied as ammonium phosphate.

†=15 N. and 19 P_2O_5 as ammonium phosphate plus 15 N. and 6 P_2O_5 as castor cake.

‡=35 N. as ammonium sulphate plus 5 N. and 40 P_2O_5 as bone meal.

§=20 N. as ammonium sulphate and 20 N. and 8 P. as castor cake.

¶=40 N. and 40 P. as ammonium sulphate and single superphosphate respectively and 20 N. as compost.

Fertilizers and Manures Applied as Treatments

Ammonium sulphate and single superphosphate were generally applied in the different treatments of N. and P_2O_5 respectively except in cases marked underneath the treatments with different signs.

Since this paper is restricted to the study of the nitrogen response curves on three different soil types of Patna district, the yield data as included in the present study comprised of responses of the treatments, 0 20 N., 30 N., 40 N., 60 N., applied exclusively as sulphate of ammonia during the years 1949-50, 1950-51 and 1951-52. Other treatments of nitrogen combined with various forms of phosphate have been excluded as they are not needed in the present study.

The yield responses pertaining to the nitrogen treatments concerned were averaged as per soilwise groupings for the different years as shown in Table 2 and standard deviations[6] were found out in each case. The average response along with standard deviations are presented in Table 3 up to two places of decimals only.

The addition and subtraction of standard deviations to and from the average mean value in each case give an idea as to how the actual responses are distributed about the mean response. Naturally, the addition of standard deviation to the mean denotes the upper limit response and the subtraction of standard deviation from the mean gives the lower limit response for different levels of nitrogen treatments included in these experiments.

A regression equation[6] of the type, $Y = a_0 + a_1x + a_2x^2 + a_3x^3$ .... (A)

Where Y = Yield response in mds. per acre

x = Dose of nitrogen in lb. per acre

a_0, a_1, a_2, a_3 are regression constants,

has been fitted respectively to the mean, the upper limit and the lower limit of responses

TABLE 3 — MEAN (AVERAGE) RESPONSE ALONG WITH STANDARD DEVIATIONS DUE TO EFFECTS OF TREATMENTS

PARTICULARS	SOIL TYPES AND MEAN RESPONSES WITH STANDARD DEVIATIONS		
	Clay	Loam	Sandy-loam
Mean of the control plots	12·60	15·50	12·90
Response of the control plot	$0 \pm 5{\cdot}31$	$0 \pm 5{\cdot}82$	$0 \pm 4{\cdot}71$
Response of the 20 N. plot	$4{\cdot}92 \pm 4{\cdot}34$	$2{\cdot}69 \pm 3{\cdot}40$	$5{\cdot}50 \pm 2{\cdot}63$
Response of the 30 N. plot	$5{\cdot}85 \pm 5{\cdot}34$	$2{\cdot}23 \pm 4{\cdot}96$	$10{\cdot}0 \pm 4{\cdot}08$
Response of the 40 N. plot	$4{\cdot}64 \pm 3{\cdot}99$	$5{\cdot}65 \pm 4{\cdot}22$	$6{\cdot}18 \pm 4{\cdot}16$
Response of the 60 N. plot	$4{\cdot}38 \pm 3{\cdot}20$	$7{\cdot}40 \pm 4{\cdot}51$	$6{\cdot}28 \pm 3{\cdot}89$

obtained due to different levels of nitrogen for each soil type which is the best fit to such observed responses. The observed average values of yield responses and the corresponding levels of nitrogen being known, the actual values of regression constants, a_0, a_1, a_2, a_3, etc., were calculated by adopting the method of least square[4] evolved by Cramer, and on the basis of these the three growth response curves corresponding to the mean, the upper and the lower limit responses for each soil type have been separately drawn. They are depicted in Figs. 1, 2, 3 for clay, loam and sandy-loam soils respectively. In drawing these curves, responses in mds. per acre (i.e. extra yields produced by the application of different levels of nitrogen as ammonium sulphate) have been plotted as ordinate (indicated in the equation as Y) and different levels of nitrogen in lb. per acre (the unit being 10 lb. of nitrogen) have been plotted as abscissa (denoted in the equation as 'x') keeping 30 lb. of nitrogen as the origin in abscissa and the average (mean) response due to control as origin in the ordinate. These are evidently shown in the Figs. 1, 2 and 3 respectively.

Nitrogen Regression Equations and Curves

Substituting the calculated values of regression constants in the general equations (A) three sets of regression equations for clay, loam and sandy-loam soils as obtained are given below which have been the basis for plotting these curves.

FIG. 1 — FOR CLAY SOIL

(i) For the mean response: (average fertility gradient soil) $Y = 5{\cdot}395 - 0{\cdot}2488x - 0{\cdot}359x^2 + 0{\cdot}1087x^3$.

(ii) For the upper limit response: (high fertility gradient soil) $Y = 10{\cdot}01 - 0{\cdot}409x - 0{\cdot}404x^2 + 0{\cdot}087x^3$.

(iii) For the lower limit response: (low fertility gradient soil) $Y = 0{\cdot}78 + 0{\cdot}097x - 0{\cdot}314x^2 + 0{\cdot}131x^3$.

FIG. 2 — FOR LOAM SOIL

(iv) For the mean response: (average fertility gradient) $Y = 3{\cdot}447 + 1{\cdot}707x + 0{\cdot}0368x^2 - 0{\cdot}0528x^3$.

(v) For the upper limit response: (high fertility gradient soil) $Y = 7{\cdot}58 + 1{\cdot}99x + 0{\cdot}171x^2 - 0{\cdot}10028x^3$.

(vi) For the lower limit response: (low fertility gradient soil) $Y = 0{\cdot}693 + 1{\cdot}038x - 0{\cdot}098x^2 + 0{\cdot}0373x^3$.

FIG. 3 — FOR SANDY-LOAM SOIL

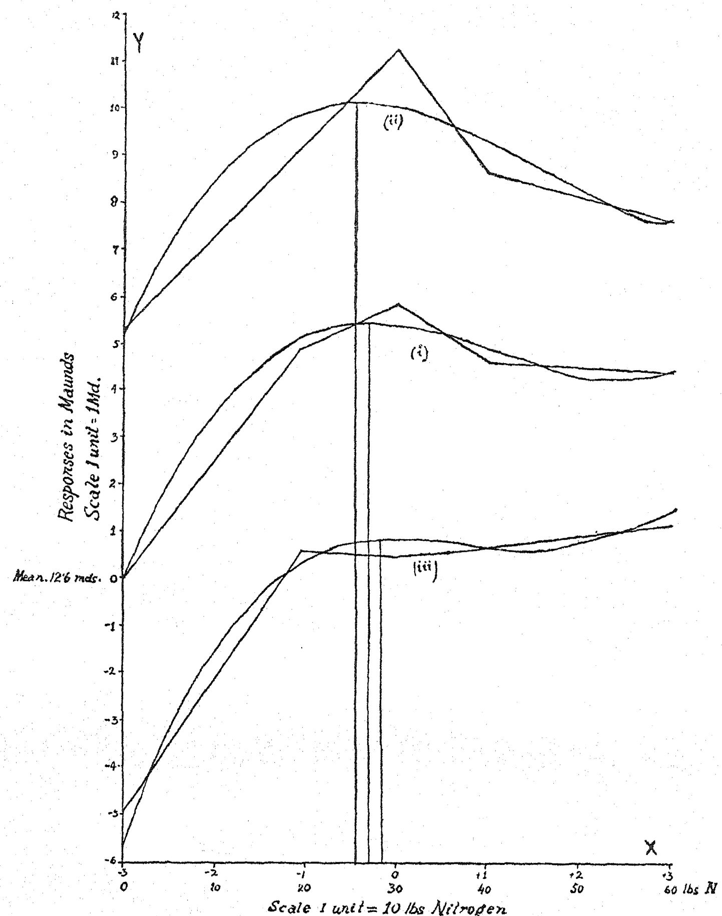
(vii) For the mean response: (average fertility gradient soil) $Y = 7{\cdot}767 + 0{\cdot}2568x - 0{\cdot}52x^2 + 0{\cdot}0877x^3$.

(viii) For the upper limit response: (high fertility gradient soil) $Y = 11{\cdot}2874 + 1{\cdot}1482x - 0{\cdot}4803x^2 - 0{\cdot}0377x^3$.

(ix) For the lower limit response: (low fertility gradient soil) $Y = 4{\cdot}06 - 0{\cdot}675x - 0{\cdot}55x^2 + 0{\cdot}21x^3$.

Since the regression equations have been formulated on the basis of the characteristic responses into three different categories as per mean or average response, upper limit response and lower limit response for each type of soil, they may be regarded to be in conformity with average, high and low fertility level gradients of soils respectively.

The response curves representing these regression equations give a true picture of the technical possibility of increasing the yield of crops due to the application of nitrogen and advices to cultivators for getting optimum response for profit due to the application of different doses of nitrogen, can be easily given deducing the information from these curves themselves. The regression equations, however, will act as necessary checks to testify the validity of deductions so obtained regarding true optimum nitrogen requirements of crops leading to their optimum yield as genuinely anticipated from the application of nitrogenous fertilizers in the



NITROGEN RESPONSE CURVE. SOIL - CLAY

Dist. Patna

Fig-1.

respective soils. As such both the curves and the equations have got great importance from the cultivators' point of view. A table (No. 4) of anticipated yield increase of paddy due to various doses of nitrogen differing at 5 lb. N. levels up to 60 N, i.e. the highest level of nitrogen tested, as deduced from the regression curves is given below for the guidance of cultivators of the Patna district, from which they will know what extra yield is obtainable due to any particular level of nitrogen which, within their means, they may like to add in their fields.

The application of nitrogen beyond optimum level as shown in Table 4 and quite apparent also from the curves is not profitable for the cultivators and as such are not recommended.

The nature of the different regression curves and their significance with full implications are discussed in detail under " Discussion ".

Discussion

Clay Soil — The equation (i) for the mean values reveals that the response Y is 0 (approx.) at 12·6 mds. (yield of control plot) at $x = -3$ and the curve Fig. 1 (i) increases rapidly up to $x = -1$ but the rate of increase $\frac{dy}{dx}$ has a diminishing tendency

TABLE 4 — ANTICIPATED YIELD INCREASE OF PADDY DUE TO VARIOUS DOSES OF NITROGEN DIFFERING AT 5 LB. LEVELS UP TO 60 N.

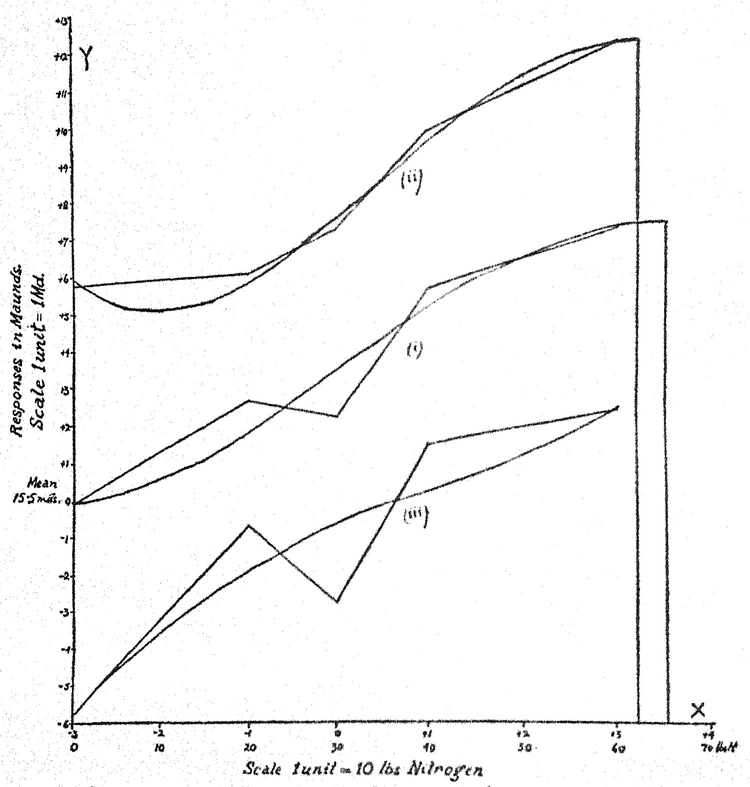
Levels nitrogen in lb.	Correspondence of S/A in mds. & srs.	Responses in maunds: Clay			Loam			Sandy-loam		
		Average fertility gradient soil	High fertility gradient soil	Low fertility gradient soil	Average fertility gradient soil	High fertility gradient soil	Low fertility gradient soil	Average fertility gradient soil	High fertility gradient soil	Low fertility gradient soil
5	0—12½	2·099	1·897	2·408	0·153	0·615	1·213	2·555	1·466	3·564
10	0—25	3·601	3·264	4·162	0·531	0·230	2·237	4·523	2·833	6·065
15	0—37½	4·583	4·169	5·366	1·065	0·533	3·100	5·967	4·036	7·661
20	1—10	5·200	4·676	6·118	1·757	0·005	3·830	6·953	5·159	8·510
25	1—22½	5·440	4·851	6·517	2·526	0·784	4·455	7·548	6·060	8·768
30	1—35	5·419	4·758	6·660	3·364	1·724	5·003	7·818	6·749	8·595
35	2— 7½	5·219	4·464	6·646	4·220	2·774	5·503	7·827	7·199	8·145
40	2—20	4·920	4·032	6·574	5·055	3·784	5·980	7·642	7·379	7·580
45	2—32½	4·642	3·529	6·541	5·829	4·655	6·465	7·329	7·301	7·053
50	3— 5	4·365	3·020	6·646	6·491	5·585	6·985	6·953	6·823	6·725
55	3—17½	4·253	2·569	6·987	7·036	6·201	7·568	6·583	6·029	6·751
60	3—30	4·377	2·244	7·668	7·391	6·525	8·242	6·276	4·853	7·290

at each point within this range. After $x = -1$ although $\frac{dy}{dx}$ has a positive value, it gradually tends to be insignificant and ultimately at $x = -0{\cdot}303$ becomes zero, after which it assumes negative values. From these it is evident that at the point $x = -0{\cdot}303$ where $\frac{dy}{dx} = 0$, Y has obtained a maximum value of 5·45 and any higher value of x will simply diminish the value of Y. No doubt the point $x = -0{\cdot}303$ where the maximum value of Y has been obtained is of importance, still the point $x = -1$, where the value of Y is 5·176, is of more importance from economical point of view, and as such it may be termed as the optimal point of the curve.

As a cubic equation has been fitted to the data, the value of $\frac{dy}{dx}$ becomes zero at two points, one of which gives the maximal response point and the second, as will be discussed later on, is not of much practical importance.

The regression curve Fig. 1 (ii) fitted to the upper limit (supposing it as representing the clayey soil having initially high fertility gradient) behaves almost in a similar manner. Here the value of Y at $x = -3$ is 5·252 and it goes on increasing with lesser rapidity till x assumes the value -1. The property of $\frac{dy}{dx}$ is similar and tends to be zero at $x = -0{\cdot}44$, where the value of Y is 10·104 giving an extra yield of 4·852 mds. per acre. Here the optimal point is at $x = -1$ where the value of Y is 9·928 giving an extra yield of 4·676 mds. per acre.

It is observed from the regression curve Fig. 1 (iii) fitted to the lower limit (supposing it as representing the clayey soils having initially low fertility) that at $x = -3$ the value of Y is $-5{\cdot}880$ and the curve increases more rapidly up to $x = -1$, having the same property of $\frac{dy}{dx}$, i.e. diminishing at each point within this range. It is seen here also that $\frac{dy}{dx}$ is insignificantly positive after $x = -1$ and becomes zero at $x = 0{\cdot}17$, after which it assumes negative values, though at a slower rate. From the above it is clear that at $x = -0{\cdot}17$, Y has obtained the



NITROGEN RESPONSE CURVE. SOIL-LOAM

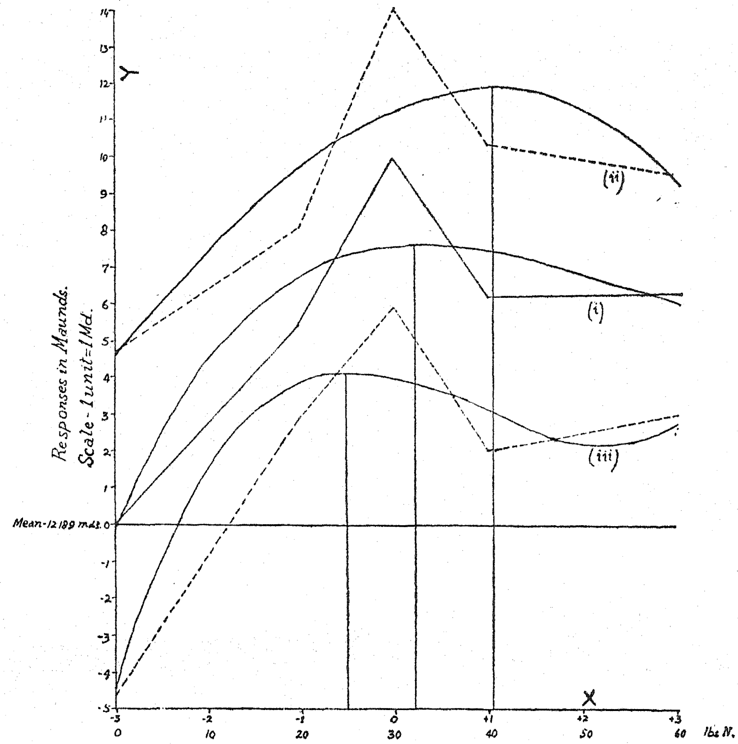
Dist. Patna.

FIG. 2

maximum value, i.e. 0·788 giving an extra yield of 6·668 mds. per acre. The value of Y at $x = -1$ is 0·238 representing an extra yield of 6·118 mds. per acre which may be taken as the optimal point.

Loam Soil — The curve Fig. 2 (i) fitted to the mean values originating at $Y = 0$ (approx), i.e. 15·5 mds. (yield of control plot) at $x = -3$, rises slowly up to $x = 0$ and thereafter rises a bit rapidly till it reaches $x = 2{\cdot}5$ where the value of Y is 7·117 denoting the extra yield over control. After this point the value of $\frac{dy}{dx}$, though positive, is insignificant and ultimately $\frac{dy}{dx}$ becomes zero at $x = 3{\cdot}586$ where Y assumes the value of 7·52. Hence, the point $x = 2{\cdot}5$ may be taken as the optimal point and $x = 3{\cdot}586$ as the maximal point, the former being more important from the economical point of view.

The regression curve Fig. 2 (ii) fitted to the upper limit behaves in a somewhat different manner. At $x = -3$ the value of Y is 5·856. After this point the curve loops down and ultimately the value of $\frac{dy}{dx}$ becomes zero at $x = -2{\cdot}05$, where the extra yield is somewhat negative which is due to the inclusion of the cubic term in the equation, as will be discussed later on. After this point the curve rises very sharply up to $x = 2{\cdot}5$, where Y has the value of 12·057 giving an extra yield of 6·2 mds. per acre. After this point $\frac{dy}{dx}$, though positive, is insignificant and ultimately it becomes zero at $x = 3{\cdot}2$, assuming the value of 12·413 giving an extra yield of 6·557 mds. per acre.



Scale 1 unit = 10 lbs Nitrogen

NITROGEN RESPONSE CURVE. SOIL - SANDY LOAM

Dist. Patna.

FIG. 3

After this point $\frac{dy}{dx}$ gives negative values. The maximal point, however, lies at $x = 3{\cdot}2$ and the optimal point is at 2·5, the latter being more important from economical point of view.

It is clear from the regression curve Fig. 2 (iii) fitted to the lower limit that at $x = -3$ the value of Y is $-5{\cdot}696$ and it increases rapidly, $\frac{dy}{dx}$ remaining positive throughout, thereby rendering it impossible to fix the maximal point from the cubic equation so adopted. If, however, the third degree term is neglected, a maximal point can be found out which can give an estimate of maximal yield possible for loamy soils of low fertility gradients. The point is at $x = 6{\cdot}855$ (98·55 lb. of nitrogen) where the value of Y is 3·912, giving an extra yield of 9·608 mds. over control.

Sandy-Loam Soil — The equation (vii) gives the regression curve Fig. 3 (i) fitted to the mean values. In this curve Y is zero, i.e. 12·189 mds. (average yield of control plots) at $x = -3$ and increase is very significant till x assumes the value $-0{\cdot}5$, which may be taken as the optimal point. At this point $\frac{dy}{dx}$ has descending tendency and here the value of Y is 7·5 mds. The maximal point in the curve is, however, at $x = 0{\cdot}2647$ where the value of Y is 7·851 mds. After this point, the value of Y decreases as x increases.

Equation (viii) represents the regression curve Fig. 3 (ii) for upper limit. Here Y is 4·538 at $x = -3$ and $\frac{dy}{dx}$ is almost

constantly positive till $x = 0$. After this point $\frac{dy}{dx}$ diminishes till x assumes the value 0·5 where Y is 11·737, giving an extra yield of 7·2 mds. per acre, which may be taken the optimal point. The maximal point, however, is at $x = 1{\cdot}062$ where Y is 11·92 giving an extra yield of 7·38 mds. per acre. On account of $\frac{dy}{dx}$ being negative, the curve further shows a rapid decrease in the values of Y at higher values of x.

Equation (ix) represents the regression curve Fig. 3 (iii) for lower limit. The curve given by this equation reveals that Y increases with more rapidity till x assumes the value $- 1{\cdot}0$ and at this point Y is 3·975 giving an extra yield of 8·51 mds., which may be taken as the optimal point.

As a cubic equation has been fitted to the yield data, the value of $\frac{dy}{dx}$ becomes zero not only at one point but at two points, one of which gives a maximal point and the other a minimal point. The first point has already been discussed but the second point indicates decline in yield mainly due to the adoption of the cubic equation that has been fitted to the data. After this point the estimate of the yield has an increasing tendency due to the inclusion of the cubic term in the equation. Although some further increase in the yield as is evident from a rise in the rate of increase of responses may arise at higher levels of nitrogen application, the evidence of this within the range of nitrogen levels tested appears slight, because it cannot be claimed that the rise in yield will follow only the cubic trend[5]. The inclusion of still higher degree terms in the equation may suppress the increase as obtained due to the cubic term. If this type of oscillation (i.e. decrease and increase) in the yield continues by the inclusion of successive even and add higher degree terms, it can only be concluded that the curve will ultimately follow the logistic trend, the general form of which is Mitscherlich's equation[3] denoted as $Y = A\ (1 - e - ex)$, where Y is the yield obtained when x is the amount of the factor present, A is a maximum yield obtainable if the factor was present in excess and C is a constant assuming that $Y = 0$ when $x = 0$.

Conclusion

The nitrogen response curves, Figs. 1, 2 and 3, representing the regression equations (i) to (ix) give a true picture of the technical possibility of increasing the yield of paddy crop due to the application of nitrogen in the soils of Patna district and advices to cultivators for getting optimum yield response for profit due to the application of different doses of nitrogen can be easily given deducing the information from these curves themselves.

The regression equations may further be utilized to act as necessary checks to testify to the accuracy of the expected optimum yield responses so deduced.

Expected yield increase of paddy due to various doses of nitrogen differing at 5 lb. N. levels up to 60 N. as deduced from the regression curves is presented in Table 4 for advisory work for the benefit of cultivators of Patna district.

The application of nitrogen beyond optimum levels as shown in Table 4 and also quite apparent from the curves is not profitable for the cultivators and as such are not recommended.

Comparing the three sets of curves for each soil type amongst themselves, with the assumption that the mean, the upper limit and the lower limit curves represent the responses having initially average, higher and lower fertility gradients respectively, it is concluded that responses on the soil of low fertility gradient will be higher than those on the soils of high fertility gradient at the same level of nitrogen.

It is further inferred that the higher the fertility gradient present in the soil, the lower will be the uptake of nitrogen to obtain the optimum response.

Comparing again the nature of the curves representing different soil types, it is found that the nitrogen requirements for a particular response in yield are higher in loam, moderate in sandy-loam and somewhat low in clay soil.

Summary

An attempt has been made to find out the nitrogen requirements of soils of the Patna district with a view to ascertain the technical possibility of yield increase of paddy crop by means of nitrogen applications alone. For this purpose, paddy yield data of a large

scale manurial experiments conducted in cultivators' fields scattered all over the Patna district have been grouped into three categories according to three main textural divisions of soils, namely clay, loam and sandy-loam. The yield data in each case were averaged separately in respect of each level of nitrogen, and their mean average responses as well as standard deviations were found out. A regression equation of the type $Y = a_0 \times a_1x \times a_2x^2 \times a_3x^3$ was fitted to these data and the value of the regression constants were determined by the method of least square.

Substituting the values of these regression constants into the general equation A, three sets of regression equations for each soil type, thus nine in total, were obtained, and on the basis of these, regression (nitrogen growth) curves were plotted out. From response curves so obtained, nitrogen requirements for obtaining yield increase of paddy crop in respect of each soil type were evaluated and also a table was prepared depicting the expected yield increase due to various doses of nitrogen differing at 5 lb. N. levels up to 60 N. only.

Acknowledgement

I am grateful to the Government of Bihar for launching and financing the Manurial Tables Scheme (now Field Experimental Service) since several years back, and to Dr. J. S. Patel, Director of Agriculture, Bihar, for putting this scheme on a better footing, which made this work possible. Further I am very thankful to Shri Nitai Chandra Das, Statistical Computor, Field Experimental Service, who has very laboriously helped me in the statistical analysis and interpretation of the data in the way in which they have been utilized in fitting up the regression equations and curves. My thanks are also due to Shri K. P. Das Gupta, Junior Scientific Assistant, Field Experimental Service, who also associated himself in the calculation of the data.

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Soil Conservation in Kosi Basin

—by P. R. AHUJA

Summary

RIVER Kosi presents very difficult problems from the view point of control of its silt and water. The third biggest Himalayan river, next only to the Indus and the Brahmaputra, it has 10 per cent of its total catchment of some 23,000 square miles under glaciers. Some of the highest peaks in the world Mount Everest and Kinchinjunga lie in its drainage area. It carries an enormous silt load. The proportion of the coarse silt to the total sediment load is rather high in comparison to several other Indian rivers. The natural geological processes, the seismic character of the region, the instability of the soil formations, a high degree of disintegration of rocks and steepness of hill slopes are some of the difficulties encountered.

A brief description is given in the paper of the reconnaissance surveys conducted by the C.W. & P.C. since 1947. Recent surveys in 1953 and 1954 consisted of taking longitudinal and cross-sections of some kholas in the Chatra gorge, collection of typical soil samples and a broad examination of the nature and extent of different types of erosion.

The chief types of prevalent erosion are broadly categorized as being due to:

(a) gully formation;
(b) hill slips; and
(c) undercutting of banks by stream flow.

Growth of vegetation, stabilization of gully slopes and beds, provision of stone revetments to prevent the drift of debris cones, blasting of boulders in the stream beds are some of the remedial measures proposed to be taken up in the coming year. To prevent undercutting of banks, construction of revetments in select reaches and spurs for diversion of stream flow are also contemplated.

Possibilities of the construction of check dams, where topographical conditions are favourable, are also under active consideration.

In addition to the implementation of actual soil conservation measures, it is also proposed to set up a field research *cum* demonstration centre and to assess the results of these measures and, in the light of the experience thus gained, extend their scope to the entire catchment.

General Description

River Kosi, the "Sorrow" of North Bihar, has many uncommon characteristics and presents some very difficult problems in its control. At its debouch into the plains it is the third biggest of the Himalayan rivers, next only to the Indus and the Brahmaputra. It drains a catchment basin of some 23,000 square miles, about 10 per cent of which is under glaciers (Table 1). Some of the highest mountain peaks in the world, Mount Everest and Kinchinjunga, lie in the drainage area of Kosi (FIG. 1). The entire Tibetan trough from Gosanathien to Kinchinjunga is drained by Arun — the longest tributary of Kosi — which comes through a gorge in the great Himalayan range. Flowing through a narrow gauge for a length of about six miles in the Mahabharata Lekh, the river leaves the mountains at Chatra and enters the plains.

Lower down in the plains, in the low-lying fan-shaped inland delta, the river has been constantly changing its course, shifting across a width of over 70 miles along a

TABLE 1

SL. No.	TRIBUTORY	AREA IN SQ. MILES	GLACIER AREA IN SQ. MILES
1.	Sun Kosi	7,330	2228
2.	Arun	13,380	
3.	Tamur	2,278	
	Total for Sapt Kosi	22,988	2,228

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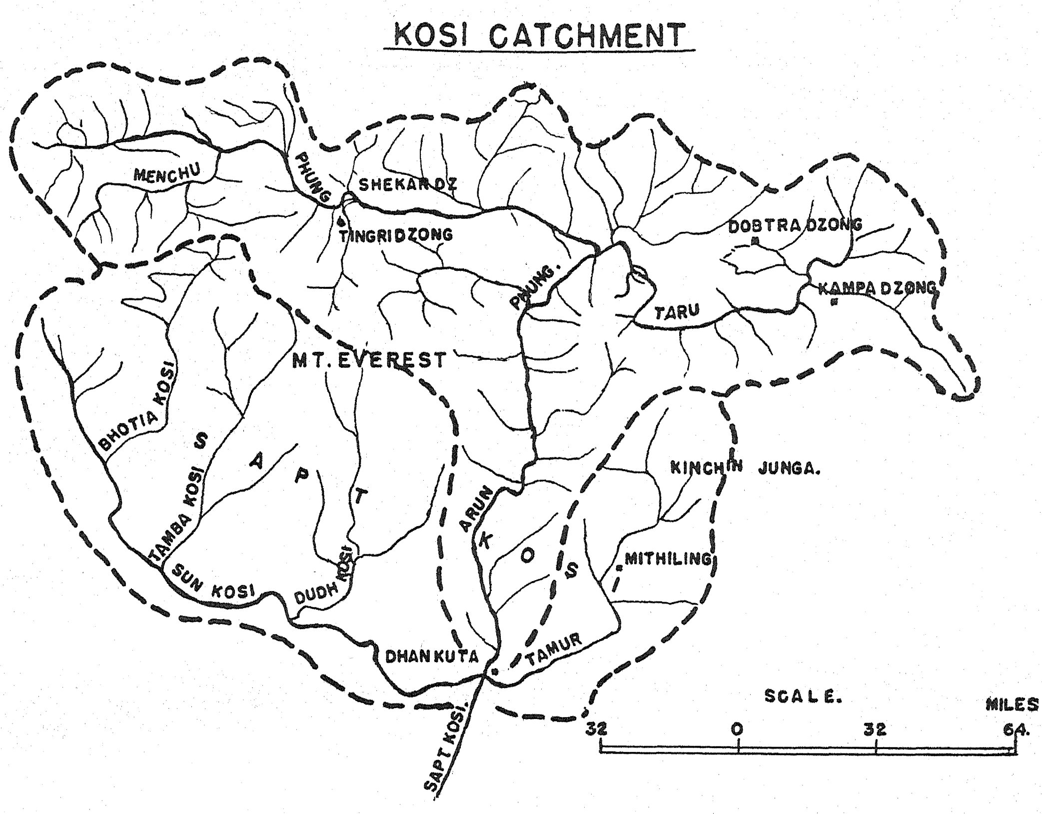


FIG. 1

cone with its apex at the point of its debouch at Chatra. The migratory trend of the river in the delta is responsible for laying waste large tracts of agricultural land in Bihar and Nepal. The resulting problems of water logging and stagnant waters in expansive depressions, serving as excellent breeding places for malarial mosquitoes, have virtually shattered the economy of North Bihar.

Silt Problem

The problem of Kosi is not only one of its enormous quantities of water, but equally one of the large masses of silt and detritus it brings down every year. There was, however, no quantitative silt data available before the C.W. & P.C. commenced investigations in 1947 in connection with the formulation of a project for the control of the river. Silt observations were, therefore, started on the main river and its three tributaries in 1947. Available silt data reveals an abnormally high rate of silt yield per square mile of the catchment, higher than that of any mountain catchment in the world for which data is available. It is also observed that the proportion of the coarse silt to the total sediment load is of fairly high order in comparison to several other Indian rivers. The river bed slope also undergoes rapid change from a steepness of 5 to 6 ft. per mile in the gorge to about 1·5 ft. per mile in the middle reaches of the river. This rapid flattening of the river bed seriously affects the capacity of the river to discharge its total silt content. The proportion of coarse silt being high, the tendency for deposition is accelerated in the flatter reaches of the river, not far away from its debouch into the plains. Slope changes and large masses of silt thus contribute to the extensive meandering and bed shift in the river lower down and causes tremendous havoc.

Reduction of coarse silt content in the river, therefore, becomes the first prerequisite for a successful solution to silt as well as the flood problem of the Kosi.

Difficulties in Planning Soil Conservation

Out of the total catchment area of Kosi, the perpetual snow line starts over 20,000 ft. Soil erosion does not occur in elevations about 10,000 ft. The catchment area below 10,000 ft., where erosion is operative, is of the order of 7,500 sq. miles. No land surveys of this area are available. Undertaking survey work in this area is extremely difficult because most of the country is inaccessible. Forest areas and grazing runs are not well defined, and agriculture is mostly shifting. Then, again, a fair percentage of erosion is from natural causes like land slips due to internal movement of water in unstable soil formations and a high degree of weathering of rock because of extreme variations of climate, steepness of slope, etc. — all factors beyond human remedy. These peculiar characteristics of the topography of Kosi impose physical limitations and warrant special treatment.

Surveys and Investigations

A preliminary inspection was made in December 1946 to January 1947 of the Tamur, Arun and the Sun Kosi valleys from the Barahakshetra dam site upwards. Indications from comparatively accessible areas, traversed during these inspections, were that the catchment was not sufficiently well clothed with vegetation. Early in the spring of 1947, an expedition was led to the upper Tamur valley in order to collect field data. The expedition went up to a height of 18,500 ft. and gathered, for the first time, valuable information about the nature, extent and degree of soil erosion, etc. After another inspection in 1948, concrete proposals for implementing soil conservation measures in Kosi were under the active considerations of the commission. No action was, however, instituted because of the fact that the commonly known anti-erosional methods of afforestation or improved agronomical practices have restricted applicability in the case of the Kosi catchment.

The analysis of the field data collected during project investigations revealed that the high content of coarse silt contributed by the three tributaries of Tamur, Arun and Sun Kosi is further increased in the gorge between Barahakshetra and Chatra as a result of increasing erosional processes in numerous small tributaries of the Kosi, locally called *kholas*, within 30 to 40 miles of the confluence at Tribeni.

Kokah khola, being one of the biggest of such tributaries, was taken up for preliminary investigations in 1953. About 10 miles in length, this khola joins the Kosi on the left bank at Barahakshetra. It has a variation in the bed slope ranging from about 15 per cent near the source and dwindling to about 2·5 per cent in the middle.

The investigations consisted of taking longitudinal and cross-sections of this khola, in addition to a broad examination of the nature and extent of different types of erosion. Typical soil samples were also collected along with a number of photographs of foci of erosion.

Similar surveys were also conducted in 1954 in the various kholas joining Tamur within 35 miles of Tribeni (FIG. 2). The Tamur catchment is taken up for more detailed examination in the first instance, because although the contribution of river flow to the main Kosi river is the least the proportion of coarse silt to river flow is the highest as can be seen from Table 3. The latter characteristics are indicative of the high degree of erosion in this catchment.

Causes of Erosion

As a result of the series of inspections and investigations, it is now possible to categorize the several types of erosion prevalent in the region. The erosion in the kholas is different from the general type of land erosion.

An engineering analysis of the prevalent types of erosion has, therefore, been undertaken with a view to suggest suitable remedial measures. The types of prevalent erosion can broadly be categorized as being due to:

(a) gully formation;
(b) hill slips; and
(c) undercutting of bank by stream flow.

In attempting to minimize the harmful effects of erosion as a result of the above-mentioned causes, it is realized that the operation of natural geological processes is well-nigh impossible to prevent. Even so,

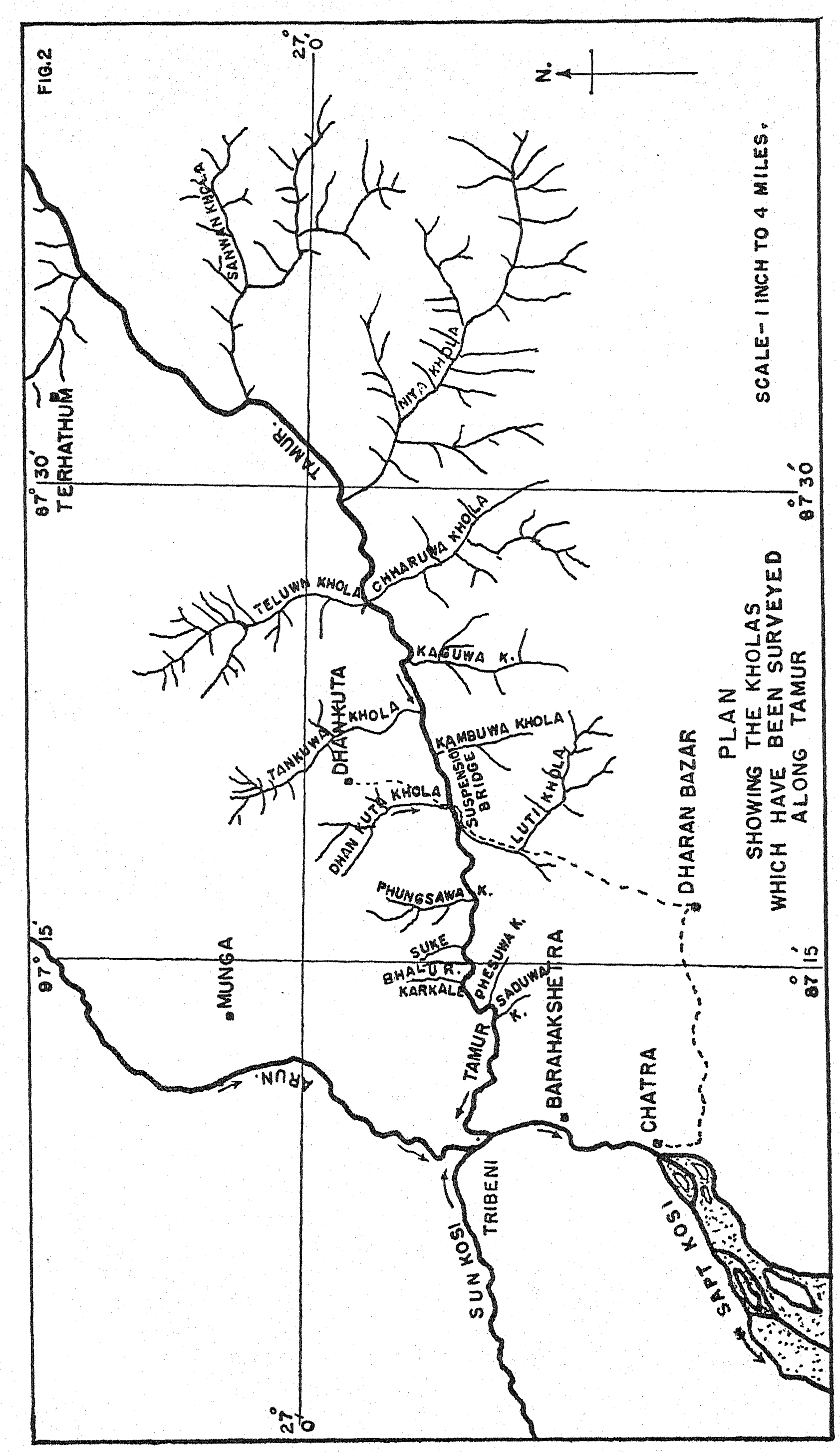


FIG.2
N.
SCALE - 1 INCH TO 4 MILES.
PLAN
SHOWING THE KHOLAS
WHICH HAVE BEEN SURVEYED
ALONG TAMUR
27° 0'
87° 30'
87° 15'
TERHATHUM
TAMUR.
SANWAN KHOLA
NIYA KHOLA
CHHARUWA KHOLA
TELUWN KHOLA
KAGUWA K.
DHANKUTA
TANKUWA KHOLA
KAMBUWA KHOLA
SUSPENSION BRIDGE
LUTI KHOLA
DHAN KUTA KHOLA
PHUNGSAWA K.
SUKE
BHALU R.
KARKALE
PHESUWA K.
SADUWA K.
BARAHAKSHETRA
DHARAN BAZAR
MUNGA
ARUN.
TAMUR
CHATRA
TRIBENI
SUN KOSI
SAPT KOSI

FIG. 2

TABLE 2 — ANNUAL SUSPENDED SEDIMENT LOAD AT BARAHAKSHETRA

YEAR	RUNOFF IN ACRE FT.	SILT LOAD IN ACRE FT.				SILT CONTENT TO RUNOFF, %
		Coarse	Medium	Fine	Total	
1948	49,395,014	10,408·03	27,993·68	45,605·33	84,007·04	0·17
1949	47,124,796	9,468·34	37,561·90	76,061·63	123,091·87	0·26
1950	42,583,834	12,087·63	21,257·62	42,163·73	75,528·98	0·18
1951	36,293,284	16,112·16	24,142·46	42,948·76	83,203·38	0·23
1952	36,499,774	16,167·92	21,813·32	42,109·04	80,090·28	0·22
1953	35,775,008	13,421·94	18,660·26	33,951·25	66,033·45	0·18
Total	247,671,710	77,666·02	151,429·24	282,859·74	511,955·00	—
Mean	41,278,618	12,944·34	25,238·21	47,143·29	85,325·84	0·21

Fine Silt	Below ·075 mm.
Medium silt	·075–·2 mm.
Coarse silt	Above ·2 mm.

TABLE 3 — A COMPARISON OF THE AVERAGE ANNUAL RUNOFF AND SUSPENDED LOAD DATA OF THE THREE TRIBUTARIES FOR THE FIVE YEARS (1948-52)

NAME	RUNOFF FROM		SUSPENDED LOAD IN FOOT ACRES				
	Foot acres	As % run-off of combined stream	Coarse	Medium	Fine	Total	
						Ft. acres	As % of combined stream
Sun Kosi	20,110,202	45	6,545·86 (·031)	15,637·81	28,725·38	50,909·05	50
Arun	16,383,388	36	7,072·47 (·043)	9,138·50	12,826·12	29,037·09	28
Tamur	8,471,329	19	3,962·93 (·047)	6,399·20	12,302·12	22,664·31	22

Figures in brackets show the coarse silt as the percentage of runoff.

an attempt can be made to prevent the disintegrated soil or rock, although dislodged from natural positions, from joining the stream.

Fig. 3 illustrates a common type of gully formation in Kokah Khola where a gully is formed at the top of the hill slip and as a result earth is washed down. In some cases there are deep gullies at the top and stone is piled up in the khola bed and debris cones of stones or soft soil are formed at the bottom, as illustrated in Fig. 5. To counteract this, it is proposed that vegetation and afforestation should be immediately undertaken in the upper reaches in the gully where slopes permit. Further, slopes should

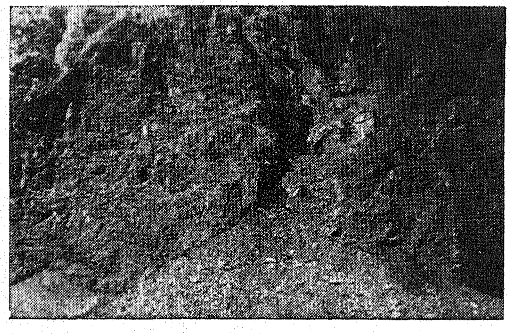


FIG. 3 — A VIEW OF A TYPICAL GULLY IN KOKAH KHOLA.

be protected by forming stone steps in small tributaries. These steps will, in addition to the stabilization of the soil formation, help to lessen the erosive power of flowing water. In the debris cone lower down, provision of stone revetments will prevent the debris being washed away by the stream (FIG. 6.)

Hill slips are a common feature in these kholas. Sometimes the slip occurs in rock and in some others in loose soil formation. These slips are mainly due to the steepness of the hill side and also to occasional earthquake tremors. Where a slip occurs in rock, the khola bed is blocked by the falling boulders. To meet a situation of this type, in addition to afforestation where possible and revetments for the confinement of debris cones, as suggested above, it is proposed that boulders should also be blasted to remove the bottleneck for stream flow. It may also be possible in some cases to construct short spurs for diversion of stream flow away from the loose bank. In respect of both the gullies and hill slips, alternative drainage should be provided for flow of water, lest these should be deepened by continuous erosion of flowing water. Figs. 7 and 8 illustrate certain common types of hill slips.

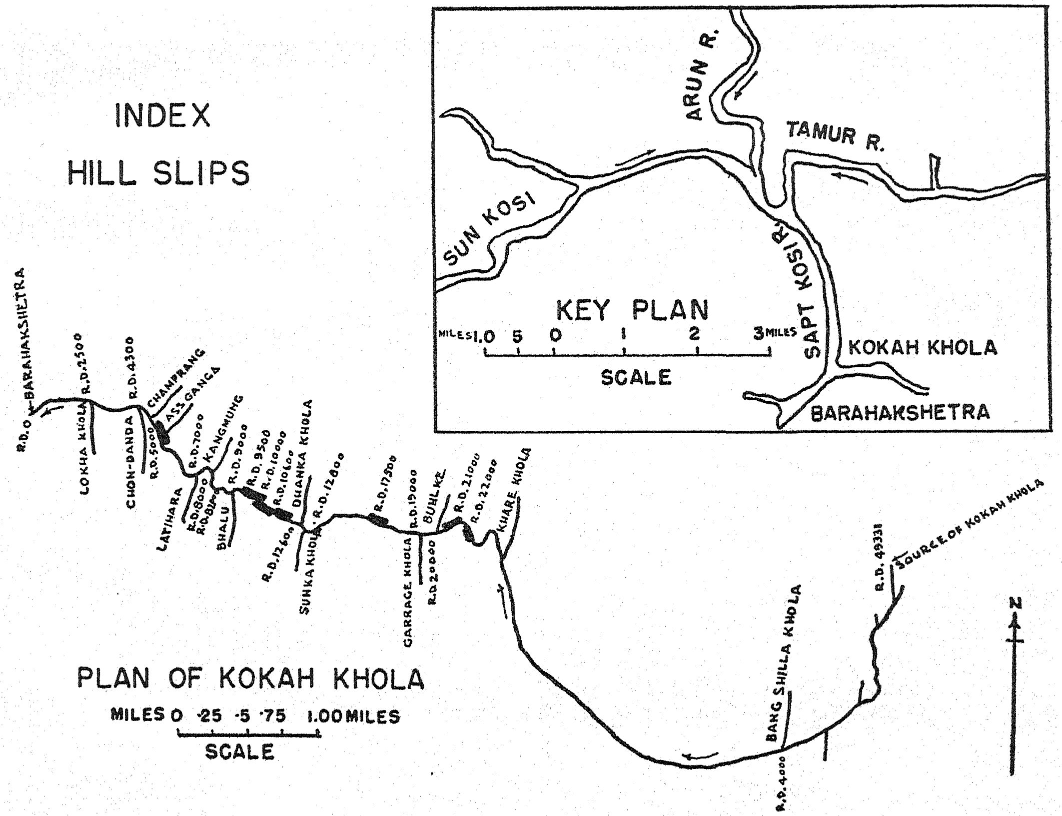


FIG. 4

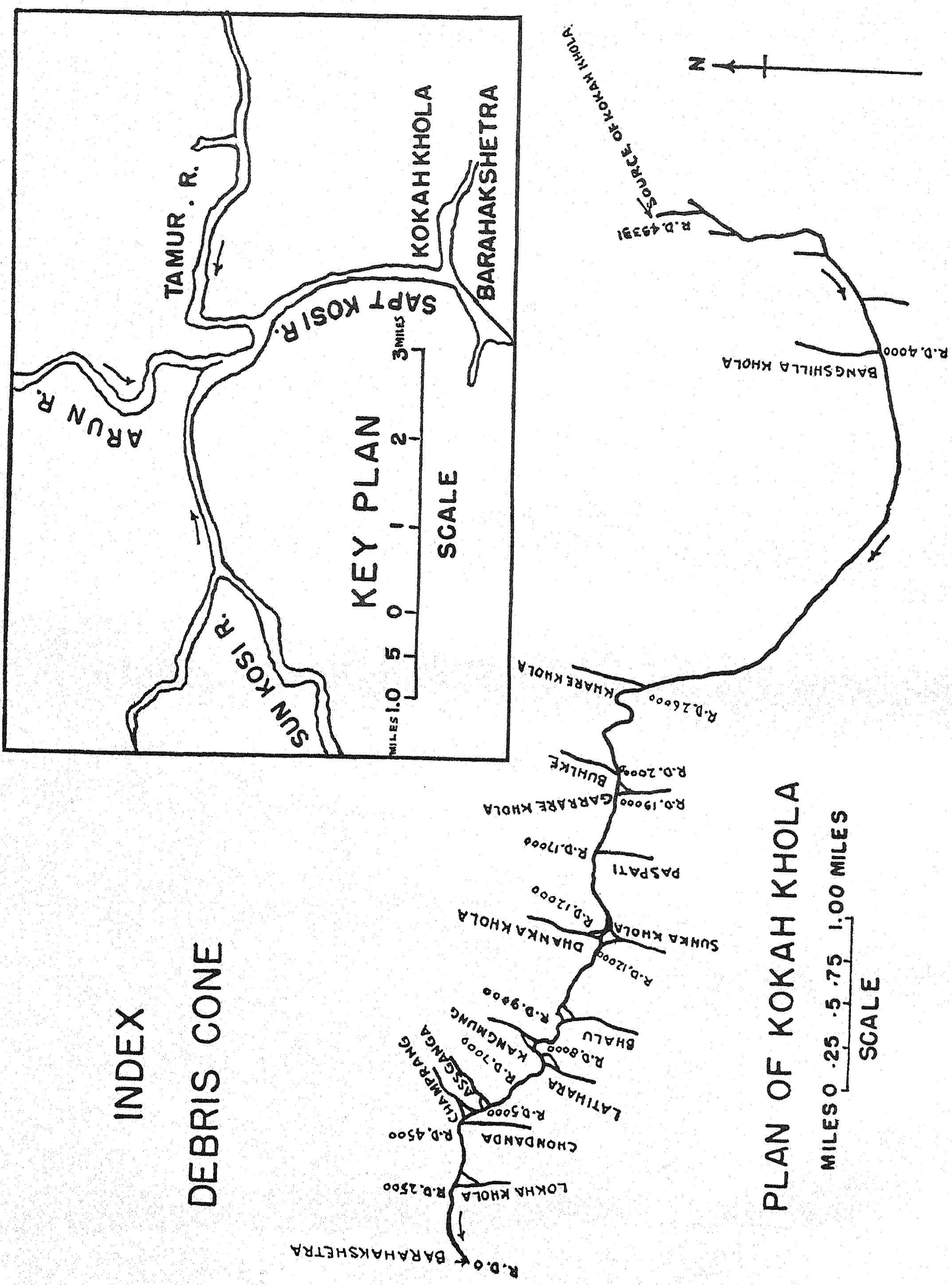

INDEX
DEBRIS CONE
KEY PLAN
SCALE
MILES 1.0 .5 0 1 2 3 MILES
TAMUR. R.
ARUN R.
SUN KOSI R.
SAPT KOSI R.
KOKAH KHOLA
BARAHAKSHETRA
PLAN OF KOKAH KHOLA
MILES 0 .25 .5 .75 1.00 MILES
SCALE
N
SOURCE OF KOKAH KHOLA
R.D. 45331
R.D. 4000
BANGSHILLA KHOLA
KHARE KHOLA
BUHLKE
GARRARE KHOLA
R.D. 17000
PASPATI
DHANKA KHOLA
SUNKA KHOLA
R.D. 9000
BHALU
KANGMUNG
R.D. 8000
R.D. 7000
LATIHARA
ASSGANGA
CHAMPRANG
R.D. 5000
R.D. 4500
CHONDANDA
LOKHA KHOLA
R.D. 2500
R.D. 0
BARAHAKSHETRA

FIG. 5

FIG. 6 — BOULDERS BROUGHT DOWN BY SUNKA KHOLA, FORMING A DEBRIS CONE IN KOKAH KHOLA.

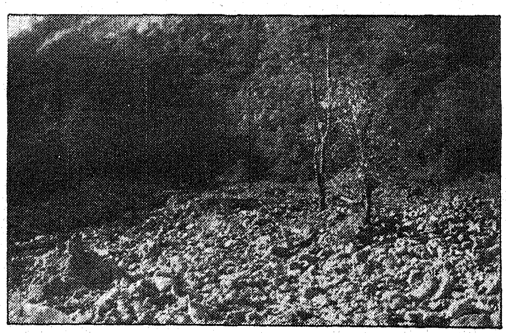


FIG. 7 — TYPICAL HILL-SLIP IN KOKAH KHOLA.

Undercutting of banks by stream flow is an important contributory factor to the sediment flow in these kholas (FIG. 9). Undercutting results from a combined operation of stream flow and the disintegration of the bank from geological and climatological reasons. Providing revetments at suitable places appears to be the only answer. Spurs also should be constructed to divert the stream flow and keeping the bank safe from direct attack of flowing water.

Where the khola is wide, long spurs should be constructed and before this spur the lower portion of the hill may be plastered with cement or provided with revetments.

Fig. 4 is a plan of the Kokah Khola showing the reaches where hill slips are extensive and Fig. 5 shows the disposition of the debris cones.

Fig. 10 is a longitudinal section of the khola. Cross-sections at intervals of one mile have also been taken along the longitudinal section and these are intended to provide valuable data for designing check dams on the main khola. The possibility of the construction of a dam at R.D. 25,000 with a height of 135 ft. is under the active consideration. This will not only trap silt from above but, by minimizing the flood volume, prevent erosion and undercutting, etc., lower down. In addition, the small quantity of power that can be generated can be used for rural electrification in the vicinity. Similar surveys and measures are also contemplated in all the kholas which join Sapt Kosi between Barahakshetra and Chatra. A list of such kholas is given in Table 3.

Action Contemplated

It is proposed to start immediately work on the construction of spurs, revetments, etc., at suitable places and also vegetation and

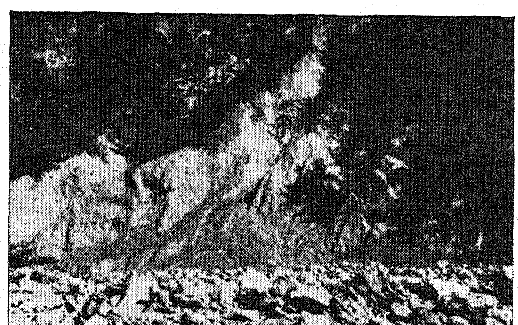


FIG. 8 — TYPICAL HILL-SLIP IN KOKAH KHOLA.

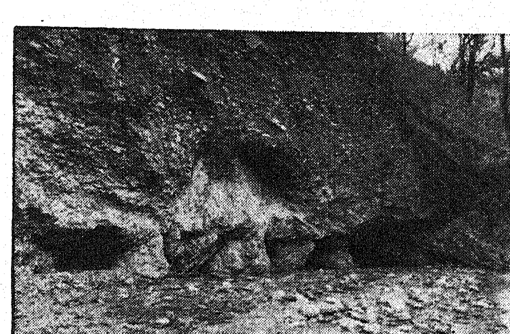


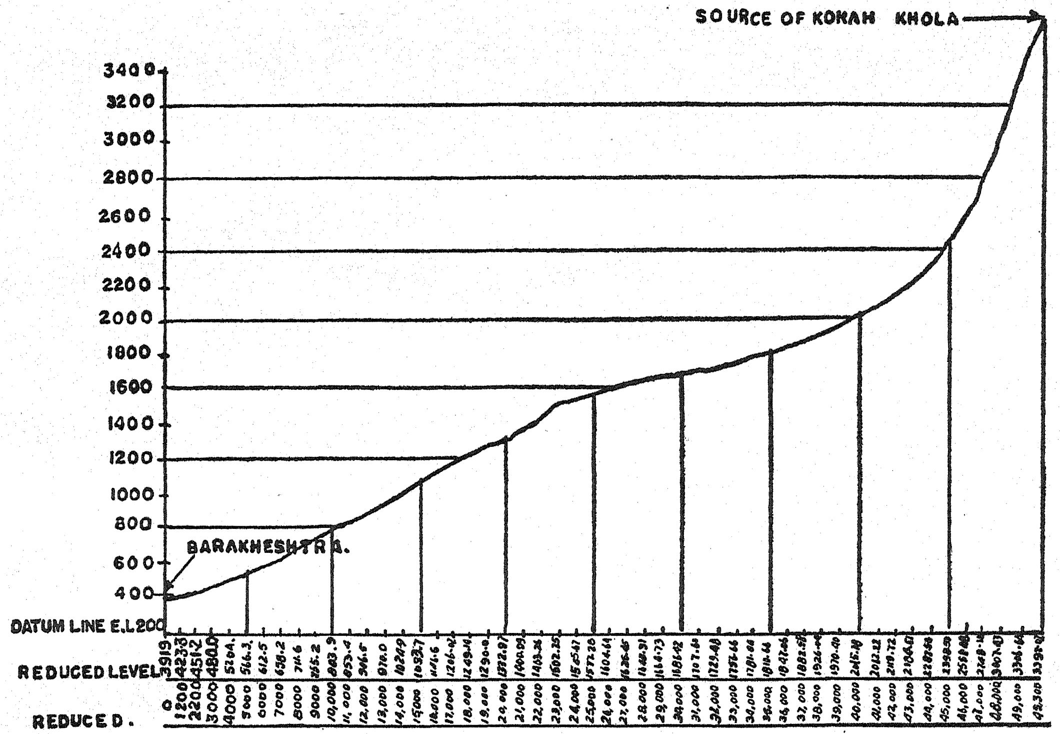
FIG. 9 — AN UNDER-CUT BANK IN TELUWA KHOLA WHICH JOINS TAMUR AT ABOUT 23 MILES FROM TRIBENI.

TABLE 4 — DETAILS OF KHOLAS JOINING KOSI BETWEEN BARAHAKSHETRA AND CHATRA (GATHERED FROM LOCAL ENQUIRY)

SL. No.	NAME	SOURCE	DRY OR FLOWING IN WINTER	BOULDERS	APPROXIMATE LENGTH, MILES
1.	Kokah Khola	Sulikot	Flowing	Small+big	9
2.	Sarswati	Kharwari	Dry	Small + big + clay in summer season	1
3.	Brahmanand	Kharwari	Flowing	Small+big with heavy clay in summer	1
4.	Jamadar Khola	Motidara	Dry	Small	1
5.	Sapt Braha Khola	Motidara	Dry	Small	½
6.	Turture Khola	Bawni Bher	Flowing	Small + big	½
7.	Murhe	Bawni Pur	Dry	Small + clay in summer	1
8.	Bawni Khola	Pipli Bhanjan	Dry	Small+big+clay in summer	1½
9.	Churi Beraona	—	Dry	Small+big+clay in summer	½
10.	Dhansar	Pipli Bhanjan	Dry	Small+big+clay in summer	1½
11.	Dud Pani Khola	Archlay	Flowing	Big	4
12.	Rani Khola	Archlay	Flowing	Small+big	4
13.	Bhraritar Khola	Archlay	Dry	Small	½
14.	Durvasa	Archlay	Water flowing up to Chatra observatory and dry below	Small+big	4
15.	Jugti Khola just opp. B.K.S. Camp	—	Dry	Big+small	½
16.	Kosapah	Sugachari	Flowing	Big+small	5
17.	Kothu Khola	Champakot	Flowing	Big+small	4
18.	Meghwari Bhaginder	(Ahale Dara)	Flowing	Big+small	5

afforestation work in select reaches. Blasting boulders and construction of small check dams are also intended to be taken simultaneously. An estimate has, therefore, been framed for an amount of Rs. 13,10,000 for undertaking this work in Kokah Khola, Brahma Khola and other kholas as in Table 4. A second estimate has also been framed for the construction of a spur in Kokah Khola for diverting the stream flow from attacking the left bank of the khola on the top of which is situated the Barahakshetra Camp.

It is also proposed to undertake detailed surveys of all the other kholas and institute field research and demonstration work, so that the results of these measures can be watched and their scope extended to the entire Kosi catchment in future. The estimate for the establishment of field research *cum* demonstration centre with headquarters at Barahakshetra at a cost of Rs. 7·25 laks during 1955-56 has already received the general approval of the Central Soil Conservation Board. The soil conservation work contemplated in the kholas is in the nature of implementing measures as distinguished from research and demonstration contemplated under the scheme approved by the Board.



L-SECTION OF KOKAH KHOLA

FIG. 10

Conclusion

The inaccessibility of a greater part of the Kosi catchment, the enormous silt flow, the seismic character of the region and natural geological processes as in the Kosi catchment offer a challenge to soil conservation. Ordinary methods of soil conservation, like contour bunding, terracing, etc., have serious limitations in view of the extreme backwardness of the agriculture in the region and also the limited proportion of cultivated area to the total area. Engineering measures, in conjunction with vegetation and afforestation work, seem to offer an effective solution to the silt problem of Kosi.

Agricultural Utilization of Lands Emerging out of Reservoirs in the Damodar Valley

by S. N. KAUL

CONSEQUENT on the formation of reservoirs by the construction of dams in the River Valley Projects, large areas of cultivable lands will be submerged. With the stoppage of monsoon rains as the water is drawn out, these lands begin to emerge. It has been estimated that the reservoirs envisaged under the Damodar Valley scheme, when completed, will alone submerge 120,000 acres including villagers' cultivated fields. This area being bottom lands in the main valley, about 50 per cent of it will be valuable agricultural fields. In the first phase of construction, the four major dams, namely Tilaiya, Konar, Maithon, and Panchet, will submerge 71,000 acres, of which 31,600 acres will emerge out periodically and be available for utilization. It is of national importance to make as much use of the submerged areas for agricultural production as possible.

The importance of irrigation to increase crop production is well known. In this region 90 per cent of the rain falls in monsoon months and due to the undulating nature of the terrain large percentage of this water is allowed to run waste. Even whatever water is made available from ponds in the region, in most cases it is just sufficient to assure a paddy crop under adverse rainfall conditions. And little surplus is left to render the cultivation of *rabi* and *zaid* crops possible. The utilization of emerging areas for the production of agricultural crops under irrigated conditions will ensure better yields and to a great extent will contribute to the increased food and fibre production in the region.

There is evidence to indicate that deposition of silt by the reservoir water tends to increase the fertility of lands by improving physical condition and also nutrient status of the soil[2]. The productive value of fields is also increased by the moisture content resulting from long flooding. This will also make the cultivation of these lands easy and profitable.

In order to utilize the emerging areas productively different methods with suitable adaptations to conform with the local environments and practices should be tried out. Such problems have not been tackled in the past in the country and this work in the Damodar Valley is a pioneering project. Results of some of the experiments obtained are not only of local interest but also can be applied to other similar areas. Several aspects of the problems have been taken up and this paper deals with the plan for early development of such an area in the Damodar Valley on an experimental basis in the Tilaiya reservoir area.

Tilaiya Reservoir

This reservoir was created by the construction of the concrete dam on the river Barakar at Tilaiya, about 8 miles south-east of Kodarma railway station in the district of Hazaribagh and is the first reservoir of the Damodar Valley Project. This reservoir has a capacity of 320,000 acre feet of water and can generate 4,000 kW. of power with an additional provision of another 2,000 kW. in future. An area of 15,450 acres of land with 1,223·8 M.S.L. (contour) is submerged when it is full. Out of this 7,900 acres are the villagers' old fields. To explore the possibility of the profitable utilization of these submerged lands a study was made of the quality and quantity of the land which will periodically emerge out of the reservoir waters. Table 1 shows the acreage available for different crops in a normal year.

The reservoir fills at the end of the monsoon. With the receding of water from October, the reservoir level reaches its lowest point — 1,192 M.S.L. by the first half of June. The cropping scheme has, there-

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TABLE 1

Month	Water level contour	Areas receded (acres) Cultivated	Waste	Total	Cropping season	Possible crops	Harvesting period
1st Oct.	1,221	749	507	1,256	*Rabi*	Berseem (*Trifolium alexandrinum*) Mustard (*Brassica juncea*) Gram (*Cicer arietinum*) Wheat (*Triticum sativum*) Khesari (*Lathyrus sativus*) Lentil (*Lens esculenta*) Linseed (*Linum usitatissimum*) Peas (*Pisum sativum*) Potato (*Solanum tuberosum*) and other winter vegetables	February to April
1st Dec.	1,218	804	540	1,344	Late *rabi*	Wheat, barley (*Hordenum vulgare*) Oats (*Avena sativa*) Potato, sugarcane (*Saccharum officinarum*) Onion (Nursery) *Allium cepa*	March to May
1st Jan.	1,215	622	710	1,332	—	Summer paddy (*Oryza sativa*) Maize (*Zea mays*) Jawar (*Andropogon sorghum*), Cucurbits	May to June
1st Feb.	1,212	590	610	1,200	*Zaid*	Bajra (*Pennisetum typhoideum*) Jawar, maize, Cucurbits (Melon, Cucumber, pumpkin, gourd, tinda, karella, etc.)	May to June
1st May	1,212 to 1,218	2,616	1,860	3,876	Second crop	Deep-water paddy, Jute (*Capsularis*)	Nov.–Dec. Aug.–Spet.
1st July	1,222 to 1,223·8	440	360	800	Kharif	Paddy and other rainy season crops including Jute (*Corchorus oletorius*)	Sept. to Nov.

fore, to be so designed that it should synchronize with the water management of the reservoir and the harvest should be gathered before the break of monsoon excepting in the case of deep-water paddy and jute (*Capsularis*) which can stand submergence, and also some sugarcane varieties which stand partial submergence.

The study of the available data reveals that an area of 11,612 acres will emerge out periodically from the Tilaiya Reservoir, of which 5,132 acres, including wastelands, will be available by February and can be utilized for the cultivation of *rabi* and *zaid* crops. On the lands situated between 1,212 and 1,218 M.S.L. contours, comprising of 3,876 acres, double cropping will be possible by following *rabi* and *zaid* crops by deep-water paddy and jute (*Capsularis*). Upland jute (*Oletorius*) and rainy season crops including short duration paddy can be grown on areas of 800 acres between 1,222 to 1,223·8 M.S.L. contours.

Soils

Soils of these areas vary widely in colour, texture, depth and reaction. A good part

of the area is covered by red loam surface with a heavier subsoil. These have been developed principally from Quartz biotite gnesiss and have got nearly neutral reaction (6·4-7·0). The rest of the area is covered by the greyish and heavier surface soil. The subsoil is very heavy and grey and contains lot of calcium concretions. These soils are calcareous, having been developed from Hornblen Schists. The reaction of the soils varies from 7·4 to 8·0.

These soils are very low in fertility, especially in nitrogen (0·015 to ·04 per cent) and phosphorus (available P_2O_5 1 to 5 p.p.m.), and are structureless. The organic matter content is also low (0·17 to 0·34 per cent).

Water

The analysis of the reservoir water collected in April and September when the water level in the reservoir was at 1,208 and 1,219 M.S.L. respectively indicate that the salt content of this reservoir water is not high for irrigation purposes and no injurious effects of salts are liable to occur. (*See* Table 2 below, giving analytical data).

Research *Cum* Demonstration

An Experimental *Cum* Demonstration farm has been set up at Sewai (Tilaiya Reservoir) in January 1954, on the old Patna diversion road which is now under submergence, with a view to explore various methods and means for the best agricultural utilization of all the lands that emerge out of the reservoir during the dry periods. In selecting the farm-site particular care was taken that the farm area comprised of both wastelands and villagers' cultivated fields and representative of the periphery from the soils point of view.

The farm has an aggregate area of 75 acres and has been enclosed with barbed wire fence. Farm soils in general are deep and heavy. Major area is of sandy clay loam. Stray calcareous patches exist below 1,216 contour. Clay increases with depth and *p*H ranges from 6·0 to 7·2. Permeability is low and lack of drainage will result poor yields in some cases.

To improve the physical condition of these soils both for better structure and internal drainage use of suitable soil amendments like compost and green manuring is necessary.

Green manure crops like Dhanicha (*Sesbania aculeata*) also provide a cover over cultivated fields during rains and save them from the effects of runoff and wave action. It can also provide food for fish in the reservoir.

The farm area has been soil surveyed and contour map at 2 ft. vertical intervals on 64 in. to a mile scale has been prepared as a base map for planning. The layout of the farm including the irrigation system was planned on this base map.

Reclamation and Layout

The reclamation and layout of the farm is undertaken according to the plan. The new land was first opened with the help of the tractor by a sub-soiler rolled by ploughing with disc plough. Blade terracer and earth scoop are used to fill up depressions formed by erosion, level up the land, construct roads and make field bunds on contours.

A shallow depression and a gully on 1,221 M.S.L. has been developed into a water intake channel dug down to 1,210 M.S.L. and connected to the dug out tank from which water could be pumped up to facilitate irrigation till the end of May by which time most of the irrigated crops would reach maturity. The irrigation channels designed to carry one cusec discharge of water are being excavated.

Graded channel terraces are designed to be built on proper locations to collect the runoff from the catchment areas above submergence and discharge the same into the reservoir through check dams provided

TABLE 2

DATE OF SAMPLING	C_{03} p.p.m.	HCO_3 p.p.m.	Cl p.p.m.	Ca p.p.m.	Mg p.p.m.	Na p.p.m.	*p*H	TOTAL SALTS p.p.m.
26-4-54	23·5	71·7	7·1	18·2	1·53	trace	8·5	160·0
1-9-54	3·0	85·4	3·0	26·5	Nil	Nil	7·5	132·0

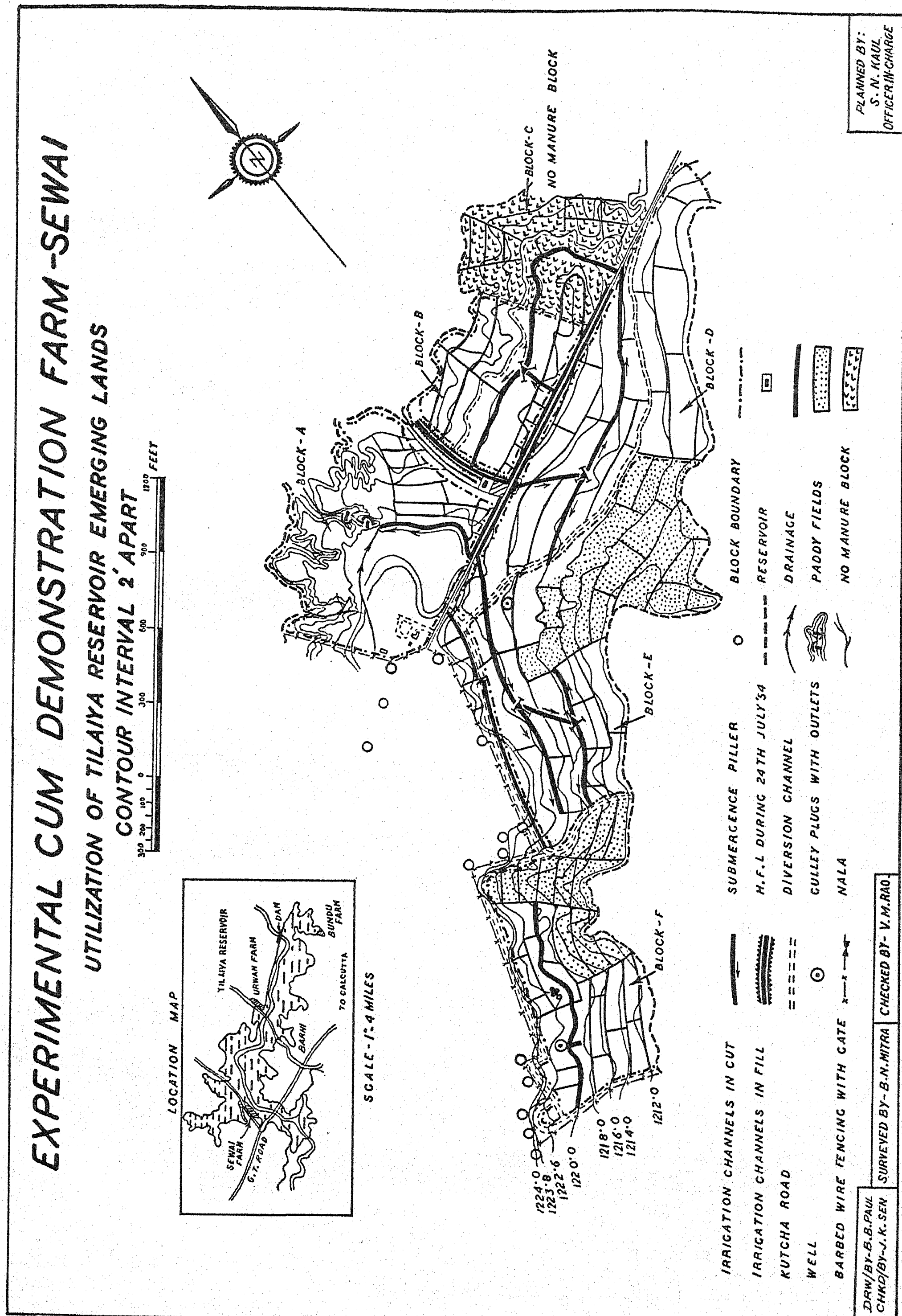
EXPERIMENTAL CUM DEMONSTRATION FARM-SEWAI
UTILIZATION OF TILAIYA RESERVOIR EMERGING LANDS
CONTOUR INTERVAL 2' APART
FEET
LOCATION MAP
TILAIYA RESERVOIR
URWAN FARM
DAM
BUNDU FARM
SEWAI FARM
G.T. ROAD
BARHI
TO CALCUTTA
SCALE-1":4 MILES
BLOCK-A
BLOCK-B
BLOCK-C
NO MANURE BLOCK
BLOCK-D
BLOCK-E
BLOCK-F
1224·0
1223·8
1222·6
1220·0
1218·0
1216·0
1214·0
1212·0
IRRIGATION CHANNELS IN CUT
IRRIGATION CHANNELS IN FILL
KUTCHA ROAD
WELL
BARBED WIRE FENCING WITH GATE
SUBMERGENCE PILLER
H.F.L DURING 24TH JULY'54
DIVERSION CHANNEL
GULLEY PLUGS WITH OUTLETS
NALA
BLOCK BOUNDARY
RESERVOIR
DRAINAGE
PADDY FIELDS
NO MANURE BLOCK
PLANNED BY: S. N. KAUL OFFICER-IN-CHARGE
DRW/BY-B.B.PAUL
CHKD/BY-J.K.SEN
SURVEYED BY-B.N.MITRA
CHECKED BY- V.M.RAO

FIG. 1

in the gully so that the silt is trapped and almost clear water let to pass into the reservoir.

Treatment of Gullies

Willow (*Salix*) cuttings collected from Kashmir and planted at the downstream side of the Charwa Reservoir at Hazaribagh are doing well. Willow is soil conserving plant and can stand water logged conditions and partial submergence. These are being planted in gullies to see how far they would stabilize them against erosion. Once established, these willows besides protecting gullies against wave action will also provide raw material for two good cottage industries in the locality. The wicker type willows will be used for preparing furniture and baskets of value and Bat willows will form a raw material for the sporting industry in the valley.

Wind Break as a Farm Asset

Due to the onslaught of hot westerly wind, the evaporation-transpiration losses of water are so high after April that cultivation in May may be considered as hazard fraught with grave risks. Plants are shaken up so badly that the root hairs of plants often get damaged. This is followed by the drying up of the plant due to the inability of roots to supply moisture to the leaf surface sufficient to cope with the transpirational losses. In order to reduce the wind velocity near the surface of the ground to protect crops against hot winds and also as partial control of wind erosion, plantation of species like *Eucalyptus citreodora*, *Cassia siamia* and *Melia azedarech* has been undertaken, and will serve as a suitable wind break. These species have been planted in a special pattern with one species to a row.

Irrigation Possibilities

Irrigation systems carrying water to the farm's need are being studied to find out what can be done about improving water delivery and cutting down seepage losses. The use of cropping methods that best fit the particular soil, slope, crop and water supply are being investigated. It makes irrigation possible without erosion damage or undue water loss.

Experiments on irrigation such as simple lifting devices to provide the best means of watering and are within the reach of villagers have been taken up. In course of time electrically driven pumps for lifting water for irrigation will also be used.

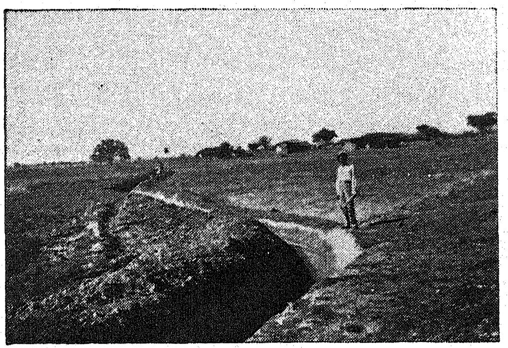

FIG. 2—1 CUSEC IRRIGATION CHANNEL.

Experiments are also being undertaken to find out the water requirements of important crops like wheat, sugarcane, paddy, etc.

Effect of Submergence on Grasses and Legumes

In case of earthen dams and embankments turfing with Giant star grass (*Cynodon plectostachyam*) has proved to be successful and effective filter to catch soil particles in the runoff on the slopes and prevent erosion of the dam. The upstream side is protected from wave action by rip-rap. To find out a suitable vegetation for lining the upstream side and also for building up permanent pastures on the reservoir periphery, grasses and legumes both local and exotic species known to possess soil binding properties were planted on a strip up and down the slope of the farm to submerge them during rainy season. This year's observation indicate that some of the species especially Dub (*Cynodon dactylon*) can stand submergence of even 4 to 6 ft. water but it is yet early to draw a conclusion. With further observations for two more seasons, some conclusions can be drown and definite recomendation may be possible in this respect.

Experiments on Agricultural Crops

Exploratory trials with crops of different varieties such as hot-weather paddy, maize, millets, pulses and cucurbits like melons, pumpkins, etc., onion, sugarcane, deep-water

FIG. 3 — SUMMER GROWN JAWAR IN A FODDER SCARCITY AREA.

paddy and jute collected from different sources were undertaken last year. This *rabi* season different varieties of *rabi* cereals like wheat and barley, *rabi* pulses like gram and lentil, *rabi* oilseeds like mustard and linseed and other miscellaneous irrigated crops like potato, peas and onion were planted for exploratory trial to find out whether they would thrive under these new environmental conditions.

Sugarcane varieties Bo_3, Bo_{24}, Bo_{171}, Bo_{11}, Bo_{14}, Bo_{28}, Bo_{22}, Bo_{453} and Duduminya (local variety) known to stand partial submergence have been planted down the slope between 1,216 and 1,222 M.S.L. (contours) to submerge them during rainy season and to determine the effect of submergence on the yield of cane and the quality of its juice. This will enable to find out variety or varieties suitable for cultivation under the emerging conditions.

The programme includes investigations under emerging conditions on manurial requirements of important crops, their best varieties, their best seed rates and optimum growing seasons and best suited cultural practices; experiments on submergence to study the fate of organic manures and phosphatic fertilizers; studies on silt deposited on the periphery lands by the reservoir receding waters, their composition and effect on the physical properties and nutrient status of the soil in relation to the crop growth are also involved.

The very close proximity of the reservoir is bound to influence the micro-climate of the area, and the relation between climate and agricultural crops including soil moisture needs a special study. An observatory is being set up at the farm for this purpose.

Preliminary Results

Paddy is the main crop of this area and the villagers prefer to grow it as it is easy for them to dispose off the surplus (in spite of the lack of proper marketing facilities in the area). This year's results show that paddy grown in summer on villagers' submerged fields (now within the farm) have given a good yield of 40 maunds per acre with paddy varieties $China_{10}$ and CH_{62}. The average yield of paddy from similar fields under normal rain-fed conditions is 8 maunds per acre. Similarly, the results obtained with deep-water paddy are quite encouraging.

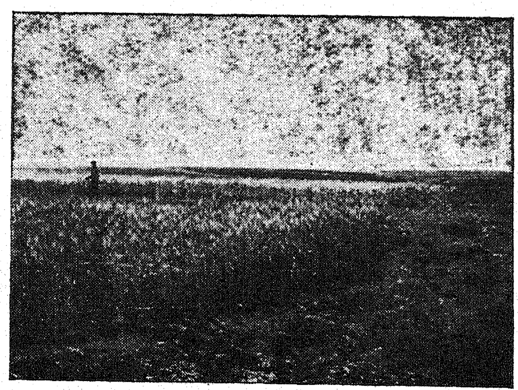

FIG. 4 — RABI CROPS WITHOUT IRRIGATION.

Jassaria and Neghari Bac (deep-water paddy varieties) have given a yield of 30½ and 22 maunds respectively per acre. The cost of cultivating this deep-water paddy compared to summer paddy is considerably lower, only Rs. 70 per acre. All varieties of deep-water paddy and semi-deep-water varieties have got the very important character of quick growth which is evidenced by their capacity to grow and keep pace with the gradual rise of water. Their duration varies from a minimum period of six-months to a maximum period of nine months. They require least attention as insect and rodent attack is negligible owing to their hydrophytic habit.

Jute (*Capsularis*) varieties collected from different sources were tried. The performance was good. Both seeds and fibre have been extracted this year, but with further trials the economics of producing this crop can be assessed.

Trials with other crops such as pulses like *mung* and *lentil*, cucurbits like melons, pumpkins and also onions have been conducted. Further trials in future will help to determine the varieties of crops that will be best in the area. The preliminary results indicate that there is considerable economic value in the proper utilization of entire emerging areas.

Demonstrations

With the objective of educating the local cultivators, it is felt essential to undertake demonstration of the best cultural practices of the emerging area based on the results obtained at this experimental *cum* demonstration centre.

The reservoir area has, therefore, been divided into three zones and for each zone a demonstration farm is being set up, 25 acres unit farms at Urwan and Bundu in addition to the existing one at the Sewai. On these farms the results of experiments on best crops and best agronomical practices suited to these areas will be especially demonstrated so that the lands ultimately leased out to the cultivators can be properly utilized. It is also proposed to extend such practices to the farmers on the lands taken by them for cultivation.

The submerged areas up to 1,223·8 M.S.L. have been acquired by the Corporation. The success at the demonstration farms will encourage the local villagers to take on lease from the Corporation such emerging areas on reasonable rental basis annually. The farm staff can move around the periphery in a boat with suitable seeds and fertilizers and demonstrate the proper layout and cultivation practices to them.

Summary

The reservoirs created by the construction of major dams in the Damodar Valley will submerge large areas including fertile agricultural lands. With the recession of water, lands begin to emerge. Such lands being considerable, their proper utilization is of national importance.

An experimental scheme for the proper utilization of such areas has been planned and is being executed in the Tilaiya Reservoir area of the Damodar Valley. This involves research and demonstration of experimental results on proper layout, irrigation, manurial treatments, selection of suitable seeds and introduction of new crops suitable to the changed environments within the time available, i.e. while the areas remain emerged. The experience of about one year's running of the project has proved to be quite encouraging. The results obtained can be extended to other river valley projects in the country.

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Improvement of Soil Fertility by Grasses and Legumes

by S. C. MANDAL

Introduction

PLANTS need a variety of minerals for nutrition, but the ones that are commonly needed by plants are phosphorus, potash, lime and occasionally magnesium and sulphur. Under certain conditions elements, such as manganese, zinc, boron, copper, iron or molybdenum, may be added to soils to advantage. Plants also need plenty of nitrogen, hydrogen, carbon and oxygen. Of these nitrogen has to be supplied to the soils in organic or inorganic forms, if its natural recuperation by nitrogen fixing organisms happens to be not so efficient as to meet the nitrogen requirements of plants. Soils contain varying amounts of organic matter which is the home of micro-organisms that are, to a great extent, responsible for the availability of nutrients to the plants. The organic matter also influences the texture of the soil. It helps in building up aggregates in the soil that lead to the establishment of a proper balance between soil air and soil water and also to the reduction of loss of soil particles from the ravages of various agencies of erosion. Thus, broadly speaking, soil fertility may be regarded as a function of plant nutrients, soil texture and microbiological activity. That is $F=f\ (n,\ t,\ b\ )$ where F stands for fertility, n for plant nutrients and other soil minerals, t for texture and b for microbiological activity. All other factors of soil fertility, such as soil air, soil water, organic matter, soil reaction, etc., may be covered by these three main components of soil fertility.

A reduction or maladjustment in any of these components would result in the deterioration of fertility. Ordinarily, the depletion of mineral nutrients cannot be avoided if the crop is harvested. Thus, in course of time, the minerals have to be replaced and experience has shown that replacement of minerals can be quickly done and it pays well. On the other hand, if the microbiological activity is slowed down due to a reduction in the organic matter content, then the organic reserves of the soil have to be built up. Again, the nature and extent of microbiological activity differs in accordance with the nature of the organic matter. Thus, in forested areas, where the organic matter has been derived from fallen leaves and the decaying roots of trees and other vegetation, it takes a long time to build up the organic matter content of the soil of good humus quality. On the other hand, grasses increase the effective organic matter of the soil, chiefly by their root growth. A healthy grass cover produces new roots every year, and the decay of the old roots adds to the organic matter of the soil. It is well known today that grass roots by their microbial and mechanical action bind soil particles to aggregates, thereby establishing better relationship between soil air and soil water. In fact, a band of workers, viz. Williams, Nikolsky, Geltser, etc.[1], after very careful experimentation have developed the hypothesis that granulation of the soil is key to soil fertility and grasses are best granulating agents. Contrarily, row and intertilled crops, e.g. maize or cotton, destroy granulation of the soil if grown continuously. Crops may be divided into two classes according to their effects on soil fertility, viz.

(1) soil depleting crops, e.g. maize, cotton, sugarcane, etc.; and

(2) soil conserving crops, e.g. lucerne, berseem, kudzu, grasses, etc.[5] Soil depleting crops may be defined as those that cause destruction of organic matter and breakdown of the structure of the soil, and not those that simply remove high amounts of mineral nutrients from the soil without causing deterioration in physical condition of the soil. For example, a crop of cotton

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may remove only as much plant food as a *dub* grass hay crop. Yet cotton should be regarded as a really soil depleting crop due to the loss of organic matter or more precisely soil binding matter, that is brought about in the wake of its cultivation. Whereas *dub* grass due to its root action conserves the organic matter and thus helps in maintaining a very good physical condition of the soil. Again, a soil conserving crop may or may not be a good soil builder. For example a small millet, such as *china,* may act as a soil conserving crop in certain areas but it may not prove to be a good soil builder. In a recent work at Sabour[4] it was found that the yield of wheat after a china crop was sufficiently lower than that after a maize crop. Thus, a truly soil conserving crop should also be a soil building crop. In fact, the concept of soil conservation should cover the maintenance of soil productivity, and those crops that best serve to maintain the productivity of a soil while being utilized are the best soil conserving crops.

It is also worth while to note that, nitrogen being the most essential plant nutrient, nitrogen-donating crops, viz. legumes, are generally regarded as fertility builders. But all legumes do not enrich soil in respect of nitrogen. Investigations at Sabour[4] have indicated that soyabean is as much a depleting crop as maize, whereas *kalai* (*Phaseolus mungo*) is an excellent nitrogen-donating crop. Since for the maintenance and improvement of soil fertility nitrogen and organic matter accretions are essential, a cropping system that is drawn up in consonance with this fact would help in keeping the productivity at a high level. Thus, in all advanced countries of the world several grass-legume associations have been marked out and included in crop rotations for the maintenance or even improvement of soil fertility.

In India very little work has been done on grass-legume combinations for pastures or leys. Whatever has been done or is being done may be regarded, generally, as isolated and amateurish attempts. Grasses, such as napier grass, guinea grass, giant star grass, sudan grass, etc., have been introduced from time to time in our country and studies have been made as regards their growth, yield of green matter, palatability, nutritive qualities, etc., in various research stations. Similar work has been done with a number of fodder legumes. All these studies have centred round the fodder aspect of various grasses and legumes but their effects, including those of various cultivated crops, on soil fertility have not been worked out systematically anywhere in this country. The Soil Conservation Research Station in Bombay, Hazaribagh and elsewhere have, however, selected a number of grasses and legumes as effective soil conserving plants. Even in these stations control of soil erosion has been the most important basis of the selection of pasture plants.

Crop yields in upland soils of Bihar, as represented by the Government farms where successful crops of maize, wheat and gram have been grown in the past, are gradually going down[4]. In some places, as in Sabour, various nutrient elements, other than N, P and K applied as fertilizer, have normally failed to push up the yield of wheat beyond 15 maunds per acre. This indicates that the fertility of these soils is going down and it must be regenerated by suitable means. Preliminary studies on the nitrogen, organic matter and aggregate status of these soils indicated that the soils have low to medium nitrogen and organic matter contents, but very poor state of aggregation[5]. Even plots that have received frequent green manuring were not found to possess a satisfactory state of soil aggregation[4]. Thus, attempts were made to find out if some grass and legume associations could be worked out that would fit in the crop rotations for a season or two and build up the fertility lost on account of exploitive cultivation associated with continuous grain farming.

Materials and Methods

It is quite apparent that any study on the soil conserving, i.e. fertility building character of different grass and legume combinations, is difficult in our country at the moment, in the absence of sufficient number of grass and legume combinations that may be introduced in our rotations as short duration leys. Thus, the first phase of the study, briefly reported here, was devoted to the collection of different grass and legume seeds from various parts of the world and their selection in respect of adaptability to local edaphic conditions, persistence, palatability, nutritive qualities, yield of green matter,

growth habits, etc.[3] Several combinations were worked out as a result of studies on the following grasses and legumes:

TABLE 1

SPECIES	PLACE FROM WHERE THE SEEDS WERE COLLECTED
Pennisetum clandestinum	Kenya (Africa)
Pennisetum pedicillatum	Nigeria (Africa)
Pennisetum stramineum	Kenya (Africa)
Pennisetum polystachyon	Kenya (Africa)
Pennisetum purpureum (Napier grass)	Sabour farm
Cenchrus ciliaris (Anjan grass)	Uganda (Africa) & Uttar Pradesh
Andropogon sorghum var *sudanensis* (Sudan grass)	Deochanda farm
Iseilema vaginiflorum (Flinder's grass)	Queensland (Australia)
Sorghustrum nutans	Oklahoma (U.S.A.)
Panicum virgatum	Oklahoma (U.S.A.)
Paspalum dilatatum	Oklahoma (U.S.A.)
Borthriochloa sp.	Oklahoma (U.S.A.)
Andropogon guyanus Kunth	Nigeria (Africa)
Cycnodon dactylon (Dub grass)	Local
Diacathum annulatum	Local
Eragrosetis curvula (Weeping love grass)	Oklahoma (U.S.A.)
Medicago lupulina (Black medic)	Queensland (Australia) & Local
Medicago denticulata (Burr clover)	Queensland (Australia) & Local
Medicago hispida (Black medic)	Oklahoma (U.S.A.)
Medicago sativa (Lucerne)	Uttar Pradesh & Sabour farm
Melilotus alba (Bubum clover)	I.A.R.I. (New Delhi)
Melilotus parviflora	Local & Uttar Pradesh
Melilotus alba (Senji)	Local & Uttar Pradesh
Trifolium subterraneum (early)	Queensland
Trifolium subterraneum (Mid-season)	Queensland
Trifolium subterraneum (late)	Queensland (Australia)
Leupedeza striata	Oklahoma (U.S.A.)
Desmodium gangetica	Local
Vicia villosa	Oklahoma (U.S.A.)
Phaseolus mungo (Kalai)	Local
Glycine max (Soyabean)	Local

A number of combinations were worked out with these grasses and legumes and their effects on soil fertility were determined from their nitrogen and aggregate status and yield of the following maize crop. The aggregate analyses were made according to the method suggested by Bryant *et al*[2]. All trials were conducted in small plots in duplicate. Prior to laying all plots were exhausted of any residual manures by intensive cropping for four seasons without manuring. The maize crop grown after grasses and legumes, too, received no manures.

Results

Several grasses from amongst those listed above were found to have put up either no or very poor growth, viz. *Pennisetum stramineum*, *P. clandestinum*, *P. polystachyon*, *Panicum virgatum*, *Paspalum dilatatum* and *Borthischlla* sp. Of the exotic grasses *Pennisetum pedicillatum*, *Andropcgon guyanus* Kunth., *Cenchrus ciliaris*, *Iscilema vaginiflorum*, and *Eragrostis curvula* grew very well during monsoon. The growth of *Andropogon guyanus* Kunth. and *Iscilema vaginiflorum* stopped after November and that of *Pennisetum pedicillatum* after February or March. The latter grass, though grew very vigorously during the rains and autumn, put up a poor growth during winter. Only *Cenchrus ciliaris* and *Eragrostis curvula* grew uniformly well throughout the year, under irrigated condition. Amongst the exotic legumes burr clover and black medic, both Australian and American, *lespedeza* and *vicia*, grew fairly well in winter. Local burr clover and black medic started growing earlier than the Australian varieties which persisted throughout the spring. All these clovers grew well for about two months and they started their growth as follows:

Local burr clover	— November
Australian burr clover	— Early December
Australian black medic	— Late December
Australian black medic	— Mid. January

All of these legumes were found to combine well with *dub* grass which is a low, prostrate type of grass. For taller grasses, e.g. *Cenchrus ciliaris*, a taller legume was found to form a good association. *Pennisetum pedicillatum* is even a taller grass and thus it would combine only with *senji*. Flinder's grass could not combine very well with lucerne, except during two months of the year, viz. October and November because of their optimum growth periods, being during rains and winter respectively. None of

these legumes can be grown satisfactorily at Sabour throughout the year. *Senji*, burr clover or black medic are winter legumes. Even lucerne which grows all the year round in the drier parts of India failed to put up a good growth during rains. Thus, a good legume to combine with *Pennisetum pedicillatum* and *Cenchrus ciliaris* and another to combine with *dub* grass, and yielding nutritious green feed for about ten months in a year still remains to be found out. Yields of green matter from different combinations are given below:

Discussion

On examining the yield data in Table 2 it becomes evident that one of the principal considerations in recommending a grass-legume mixture for pastures being the maximum yield of green feed, the *P. pedicillatum*-senji and the *C. ciliaris-lucerne* combinations may be regarded as better than the rest. On the other hand, considering their effects on soil fertility the *dub* grass-burr clover mixture, yielding only 390 maunds of green feed per acre seems to be better fertility building combination than others. Burr clover as found out in a previous study[3] adds considerable amounts of nitrogen to the soil and the present studies indicate that *dub* grass is fairly efficient in increasing the aggregation of the soil particles. On the other hand, nitrogen donated by senji though quite high could not raise the yield of maize as much as the burr clover-*dub* grass treatment owing to the fact that the grass *P. pedicillatum* failed to bring about any improvement in the physical condition of the soil. Thus, for the maintenance or improvement of soil fertility, i.e. soil conservation, a *dub* grass-bur clover combination may be included in crop rotations to advantage. The sward produced by this mixture is quite thick and should act as effective controllers of soil erosion as well in areas of 1 to 2 per cent slope. The combination may be improved by introducing seeds of black medic, both local and Australian, in the mixture so that the supply of leguminous fodder and nitrogen donation may continue for a longer period. Where only canopy effect and vigorous growth are aimed at, the *P. pedicillatum*-senji combination should be regarded as useful. This

TABLE 2 — YIELD OF GREEN HERBAGE IN MAUNDS PER ACRE FROM DIFFERENT GRASS-LEGUME ASSOCIATIONS

Grass-legume association	Yield per acre in mds.	Period of growth	Remarks
1. *Dub* grass-Burr clover	390	July to April	No legume during rains
2. *Dub* grass-Black medic	335	July to May	No legume during rains
3. *C. ciliaris*-Lucerne	715	July to June	Poor growth of lucerne during rains
4. Flinder's grass-Lucerne	501	July to June	Poor growth of lucerne during rains and no grass during winter
5. *P. pedicillatum*-Senji	890	July to April	No legume during rains

Effect of these combinations on soil fertility were studied in respect of percentage of water stable aggregates, total nitrogen, nitrate nitrogen, ammoniacal nitrogen and the yield of the succeeding crop of maize.

TABLE 3 — YIELD OF MAIZE, NITROGEN AND AGGREGATE STATUS OF SABOUR SOIL AS A RESULT OF GROWING GRASSES AND LEGUMES IN THE PREVIOUS SEASON

Previous cropping system	Yield of maize grain in mds. per acre	Percentage of water stable aggregates greater than 0·25 mm.	Percentage of total nitrogen
Fallow	2·20	5·80	0·017
Dub grass alone	4·90	15·00	0·026
Dub grass-burr colver	6·10	26·30	0·041
Lucerne alone	2·10	7·00	0·024
C. ciliaris-lucerne	2·60	5·00	0·020
P. pedicillatum-senji	5·00	6·00	0·037
Flinder's grass-lucerne	2·10	6·20	0·015

combination too may be improved by growing *kalai* in combination with *P. pedicillatum* in alternate rows and drilling in senji after the harvest of *kalai*. It will, however, necessitate the working of the soil again in October and thus may not be liked by some soil conservationists, but in view of the rich nitrogen-donating character of senji and *kalai* and the ease with which they can be drilled in with a dressing of phosphate, the combination still stands the promise of being considered as a good soil-conserving pasture mixture.

In conclusion, it may be stressed that improvement of physical condition of our upland soils is extremely essential for our agriculture. Green manuring addition of composts, application of synthetic soil conditioners, etc., are some of the ways to achieve this end. But the natural and most universal method is to put down the land to pasture for some time. Moreover, our semi-started cattle population too demands a change in our cropping systems. Therefore, our agronomists, chemists and soil conservationists should work together to save our soil and livestock. The work indicated here is only a desparate attempt of a very modest nature. We have yet to make a beginning in this direction.

Summary

A need for introducing grass and legume combination in our rotation has been pointed out.

Several grass and legume associations have been worked out and their yields have been compared.

Effects of these combinations on soil fertility have been indicated.

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Social and Economic Aspect of Indian Farming People in Land-use and Soil Conservation Programme

by R. V. TAMHANE

"SOIL conservation in its broadest sense implies permanent maintenance of the productive capacity of the land. The achievement of soil conservation not only requires that the land be used for the purpose for which it is best suited, but also necessitates the adoption of such soil conservation practices as are required for each kind of land." The foundation plans based on physical factors like land and its productivity cannot be more effective unless due consideration is given to the economic and social condition of the farming people.

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The planning and operations of a programme designed to conserve land and put it to its most effective use in terms of the welfare of the people is actually a difficult task, specially under Indian conditions. The three factors on which any soil conservation plan is based, namely physical, economical and the rural factors, are so inter-related that they must move forward in constant balance and co-ordination, if the programme is to be successful. Among the economic factors, the most significant factor in determining the character of the land problem of

a nation or even for a major regional sub-division is the density of population in relation to the degree of industrialization. Where economy is predominantly industrial, a much larger population can be maintained without excessive pressure on agricultural land resources, especially where industrial products are exchanged for agricultural products or where a large proportion of rural population is engaged in growing cash crops, but if the majority of the population has to depend mainly on agrarian products as is the case in India where 75 to 80 per cent of our population is mainly engaged in agriculture, the problem assumes a different outlook.

Economic Conditions of Our Peasants

The economic and social life of our peasants is very much intermixed with our present-day agriculture. In parts, their mode of living is age old and traditional and is very much preserved through isolation from towns and cities and in parts it reflects the direct relation to the available land resources, intensified by high birth rates, isolation from industrial towns, lack of proper education either in any technical branch of any cottage industry or in three 'R'. The poor state of health and high illiteracy (in India the illiteracy is appalling and the total percentage of illiteracy above the age of 5 years is 85 per cent) and under-developed transport facilities, the primitive methods of cultivation, poor health of cattle — the so-called wealth of our peasants — and low income of our farming people are the main causes of her backwardness. All these facts lead any one to form a concrete idea about the deplorable economic condition of farming people.

The Indian agriculturist, however, has many handicaps and obstacles to overcome to reach the level of a well-developed country. The chief character of our farming is that nearly 80 per cent of our 360 million people are engaged in farming and have to depend on food and fibre produced by our peasants. Our farming methods are not on commercial lines, the yields per acre are miserably low and the annual increase in our population of the order of 5 million per year is not balanced by the increase in production of food and fibre. India has a total area of 1·5 million sq. miles, i.e. 37 per cent of the world's total area and she has to maintain over one-fifth of the world's population. In contrast to India, U.S.A. has a population of 170 million people with a total area of 3 million sq. miles and with an average density of population of 50 per sq. mile. The holdings vary between 400 to 600 acres per family and only 20 per cent of the population is engaged in agriculture. In India there are areas, specially the deltaic regions and the gangetic valley which are over-populated — population ranging from 450 to over 1,000 per sq. mile, while there are vast territories in Rajasthan, Madhya Pradesh and even in the Deccan where density is meagre, but an overall average will be about 240 per sq. mile. Similarly, the cattle population in India is about 210 million, nearly one-third of the world's entire population but the production of milk in India is only one-fifth of that of Europe. Compared with India, Canada produces 25 per cent milk with only about 6 per cent of the cattle. Due to poor quality of Indian bullocks, deep ploughing has become an exception rather than a rule. To this poor quality of bullock, as calculated by Dr. Burns, falls the lot of cultivating nearly 11 acres per pair.

On the side of farms and lands the fertility of our land has gone down. The primitive method of cultivation is giving very low yields, the average yield per acre of most of our important cereals is perhaps the lowest in the world. The vagaries of rain and protracted drought have resulted in uprooting large number of families from the soil. Although rainfall is the limiting factor in crop growth in our country, yet adequate irrigation facilities are not available. It has been estimated that including irrigation of every description seven-eighth of our agriculture is yet dependent on the vagaries of monsoon and as such the land under crop-production could not increase and keep pace with her increase in population. Naturally, under the dependence of rain, the farming system has mostly remained as single cropping system with all its disadvantages. Usually, single crop-agriculture fails either to bring return for good living to the tillers of the land or to maintain the productivity of the soil. Even where the soil is very productive and less likely to be injured, single-crop farming usually means a poor living for the cultivator and also to his cattle wealth who do the work for him. Moreover,

if the price of one crop for some reasons goes down to a very low level for a long time, the farmer may be completely ruined. One-crop farmer may be rich in one year and poverty-sticken in the next. The natural calamities over which he has no control even things like insect attack and plant disease may ruin the crop — the only crop over which he spends all his labour and energy. In many cases the holdings are very small with little area under cash crops. In areas where cash crops, like sugarcane, cotton, tobacco, jute, etc., are the mainstay of the cropping system, the economic condition of the farmer is very much better, while, on the other hand, agricultural commodities are not themselves homogeneous group and the prices of some commodities have always average higher value than those of others in relation to the parity level and it is difficult to maintain the prices of two or more groups of commodities at the same relative level in changing market. For the permanent and secure agriculture, therefore, one crop system will be always liable to incur insecurity. The living of thousands of farm families and their security of farming can be greatly improved by growing more commercial crops or mixed farming wherever possible.

Farming is also an enterprise in which the returns from the land, the cost of cultivation operations and the labour usually accrue to the same level, so that most farmers find it impossible to reduce the cost of cultivation during period of depression, as do some industrial operators, either by cutting down the number of labour employed or by refusing to pay rent. These two conditions, namely the instability of income under single crop system and the fluctuation of commodity prices, combined with a continued pressure of population on the land, tend to make it difficult to obtain substantial downward adjustment in crop growing. Secondly, our village folk is so little in touch with the world market—because of our low literacy—wherein the results of his labour are evaluated and sold in such a way that a large portion of his profit is intercepted by the intermediate agencies. Many of our most serious rural problems emerge from the fact that too large a proportion of our population is endeavouring to make a living on farming with the result that manyfold divisions of our holding into smaller units have resulted. The income and living standard of the farm population have reached to a staggeringly low level. The inadequate income of agricultural people has forced the rural population to go into debts from which they never recover. Most of the debts of agriculturists in India are used for unproductive purpose, while in advanced countries it is mostly incurred for productive purpose. "To a very great extent the cutlivator in India labours not for profit nor for a net return but for subsistance" (Agricultural Commission Report). In India the annual income *per capita* is remarkably low as compared with other developed countries like U.S.A., U.K., Canada and Australia. It is only Rs. 255, in India whereas in U.S.A. it is Rs. 4,643, in U.K. Rs. 2,356, Canada Rs. 2,826 and Australia Rs. 2,100.

Ill-balanced Industry and Agriculture

Our agriculture and industry are ill-balanced. It is very essential, if proper balance is to be maintained, that due emphasis to the production in villages not only on agricultural side but necessarily on industrial is given to. The economic depression in rural life has come because of failure of industry to absorb the annual increase in our population. The ill-balance of agriculture and industry is specially serious because of its fluctuating character of farm income, coupled with the natural calamities like famine and floods that introduce the instability into rural life. In time of industrial prosperity rural population is drawn into cities. In depression large and burdensome number returns to rural areas for support. Our farming has not reached the stage of commercial farming whereby a large family can be supported without any difficulty. A large proportion of our farm families are employed, primarily in production for family use, with at best the incidental production of small quantities for sale. Industrialization will help to eliminate certain of our chronic defects in agricultural economy, such as subdivision and fragmentation of our holdings and will help to keep a balanced economy. Industries in India have been famous in the past. During Vedic Age, which roughly extends from 2,500 B.C. to 500 B.C., the Indian Sub-continent was economically flourishing by a gradual progress and advancement in agriculture, cattle and other trades. India was rich with people

engaged in arts of weaving, tanning, metallurgy, carpentry, blacksmithy, and many other artistic crafts. Under Vedic period there was a well-organized system of industry and agriculture with a balanced self-sufficiency prevailing all over. This age-old balance in our economy was destroyed under different period of ruling race. The decay of indigenous industries in India can be traced from the last stages of the Moghul Empire in India and the advent of the East India Company. Although a formidable percentage of the entire population of our country is dwelling in village, yet the development of the rural industries has been neglected in the past, and considering the long idleness of our peasants for a major period of the year, it is very essential to use them in some useful industry whereby a balanced use of their labour is made to increase their annual income. With the development of community projects, many of our handicaps in the development of rural life are expected to be eliminated.

Soil Conservation under Rural Economy

India and China, however, are aging naturally, their soils are becoming worn out through long use and the erosion. On the other hand, Japan and Java, with highly erosive topography and climate supporting 500 to 680 people per square mile respectively, have controlled erosion to a great extent. In certain regions of India there is a great necessity of changing from a relatively intensive to a relatively extensive type of farming. A dense population up to a limit which the land can support is indeed the best insurance against the forces causing erosion. The densities of population give every acre of land a national value. The closely packed and immobile people must be compelled at all cost to conserve their soil. So long as the population remains high, adequate protective measures against soil exploitation are absolutely necessary, otherwise uncontrolled erosion would inflict immediate disaster to the people. Proper and efficient land use to get the maximum permanent prosperity to its inhabitants should be adjusted on the basis of soil-climatic factor. The regional approach is necessary in land use, because land problems are usually of a regional nature and needs such an approach and solution. For example, in Australia sheep breeding and wool industry is adjusted in regions where rainfall is low and soils are suitable for pasture. There the holdings, too, are adjusted according to the carrying capacity of a field and extend from nearly 1,000 to 4,000 acres per family. Thus, no excessive pressure of grazing is brought upon the soil to bear. Similarly, in irrigation districts where cropping is intensive the holdings are restricted to not more than 400 acres. In India such a change is very necessary specially in areas where inadequate rainfall is a rule rather than exception, so that farming family can adjust a variety fo crops under the natural environment to make a decent living. The soil conservation methods, however, may be useful and helpful in increasing the productive capacity of our land, yet the economic conditions of our farming people are at such a stage that no individual cultivator is in a position even to try these useful methods on his farm because of so many factors mentioned above. Yet, the conservation of our soil is of paramount importance in our agricultural economy, considering the vastness of the problem and inability of our farmers to take individual action in soil conservation, the best plan under the circumstances would be to tackle small watersheds in different regions as a suitable unit to start with, in controlling and reducing damage from floods or siltation. The aggregate results of these watersheds as a whole in reducing damage from floods will be an example to the farmers to understand the importance of soil conservation measures. Similarly, plans should be drawn to bring the principal rivers and water resources of our country into inter-locking system under complete human control. By means of locks, barrages and canals, linking together of river system as well as separate rivers in each region is necessary. The principal aim in India should be that floods and drought will be disciplinary measures which man and not nature will exercise. The reconstructions of rural life should be such that not a drop of water, the shortage of which alone holds back the advance of our agriculture, is wasted. This will be the real basis of soil conservation plans in India.

Notes, Correspondence, News, Etc.

READERS OF THIS JOURNAL WOULD BE INterested to know what was thought of Soil Conservation, as we now understand it, over 2,000 years ago.

"At the period, however, with which we are dealing when Attica was still intact, what are now her mountains were lofty, soil-clad hills; her so called shingle plains of the present day were full of rich soil; and her mountains were heavily afforested — a fact of which there are still visible traces. There are mountains in Attica which can now keep nothing but bees, but which were clothed, not so very long ago, with fine trees producing timber suitable for roofing the largest buildings; the roofs hewn from this timber are still in existence. There were also many lofty, cultivated trees, while the country produced boundless pastures for cattle. The annual supply of rainfall was not lost, as it is at present, through being allowed to flow over the denuded surface into the sea, but was received by the country, in all its abundance, into her bosom where she stored it in her impervious potter's earth and was able to discharge the drainage of the heights into the hollows in the form of springs and rivers with abundant volume and a wide territorial distribution. The shrines that survive to the present day on the sites of extinct water-supplies are evidence of my present hypothesis.

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THE ANDHRA AGRICULTURAL JOURNAL, published by the Agricultural College Union, Bapatila, Andhra.

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ANNOUNCEMENT

At the invitation of the Government of Patiala & East Punjab States Union, the Fourth Annual Meeting of the Soil Conservation Society of India will be held in Patiala from the 26th to 28th December 1955 (Provisional). The details of the programme of the meeting will appear in the next issue of the Journal.

Editorial

THE good earth on which we are born, from which we draw all our sustenance, and to which we go when we die, is taken for granted and misused. Only when the soil, tortured beyond endurance, revolts and hunger stalks the land that people wake up to the most basic problems of human survival. Man's relationship to land and man's relationship to man with regard to land constitutes much of human history.

When man separated from the apes and came down to land from tree tops as a carnivore, perhaps about a hundred thousand years ago, his intimate relationship with the soil began. Even as a hunter there must have been some favoured hunting grounds with plenty of game and some caves affording better protection from enemies and inelement weather creating the beginning of localized attachment to land. The taming of the wild animal started early. Possibly the wolf dog as a hunting companion came first and then came the ass, the camel, the cow and the goat and sheep, tamed and available for eating when the hunt failed — the earliest precursors to tinned milk and meat and transport. Accumulation of herds of cattle probably started most of the problems of human misuse of land. Instead of wild game that wandered about to wherever there was pasture and returned what they ate in the form of fertilizing excreta a large number of animals were tamed and confined to closed areas for protection from carnivora. And when they grazed and over-grazed the limited areas and took off more grass than the soil could produce, the seeds of the desert were sown. Some people believe that the march of the desert into the ancient towns of central Asia and Persia were due to this. And nomadic groups with large herds of cattle and other grazing animals started shifting from area to area leaving deserts behind.

The taming of the plant came much later. The wheat of Afghanistan, the rice of India and the dals of the Hindustan plains were adopted and cultivated. Ploughing, sowing, reaping, manuring and irrigation from wells are mentioned in the *Rig Veda*. Plato and Chanakya several centuries before Christ knew a good deal about the proper use of soils. Agriculture anchored human groups to land — perhaps hardly ten to twenty thousand years ago. During this short period man has managed to do considerable damage, ruined some of the best soils beyond redemption and is well on the way to losing soils on other areas of cultivation. Deforestation of neighbouring areas for crops started with increasing human and cattle population. Pressure on land increased giving rise to the problems of possession with limitation of availability. The overall right of the Chief or the King created the dominant title and the complication of title in, and

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possession of cropped lands vesting in different persons started. A feudal personal relationship between the owner and the cultivator developed into innumerable types varying from one extreme of ownership with slave labour entitled only to subsistence to the other with almost complete ownership in the cultivation, the owner retaining only the right to levy a nominal rent. It is natural that such relationship based on relative strength could not continue to govern the vast majority of the population and the State has stepped in as the landlord where it was not so. It is a case of nationalization of a human activity that affects so many. But cultivation of land continues to be the private industry par excellence. Social mores and traditions have charged land with a value far in excess of its economic rights. Man's attachment to land that gives him shelter and food is ancient and the high social value renders it in intensity only next to man's attachment to his mate; and the fact also remains that majority of the people in this country have way of living open to them except on land. Hence it is that land problems that dominate the picture. Public, joint and individual ownership, and cultivation of land draw much attention. The Bhoodan movement, efforts at collective and co-operative cultivation, co-operative arrangements for facilities of cultivation, ceilings on the maximum areas to be cultivated by one person, increasing the right of the temporary cultivator and share-croppers and various other movements have for their objective, social justice between people who eke their livelihood from land. The maximum permanent production through the best possible use of land becomes the secondary objective often. The conflict between the two objectives is inevitable, and the danger of starvation to the community as a whole, however distant, by failure to secure that form of agricultural production from the land that gives the greatest yield permanently is very much there.

Agriculture is not the only use of land. Nature's cropping pattern is the forest — heavy tropical jungle or temperate timber forests or brush wood jungle or mere grass according to the soil and climate. Forests have great economic value as they produce timber, fuel, fodder and various kinds of other products of great importance. They also provide grazing for cattle and a home for wild game in the delicate balance of nature. But forests are largely owned by the community or the State and what is everyone's property is no one's property and is least looked after. Rights and privileges rather than restriction and duties develop in forests and grazing lands to their detriment. The other types of land use are areas under perpetual snow and desert and the areas required for towns and roads, tanks and orchards and industrial settlements.

The period of human history, during which comparative safety from rivals of the animal world has allowed agriculture to develop and the human population to multiply causing pressure on land, is but a fraction of the history of man. The feeling that land, good land, is available in unlimited quantities and we have only to wrest it from nature's forests dies hard. Floods and droughts, famines and pestilence with their disastrous consequences have been frequent and spectacular, and the slowly deteriorating balance-sheet of diminishing soil assets in the face of wasteful uses that constitute the background for such calamity has tended to be overlooked. That all human wealth comes from the soil, out of what grows

out of it, and what lies underneath, developed by human skill and endeavour is a patent thought which is still to be realized all round. In commercial language good business means the husbanding of the capital invested with provision of adequate sinking funds and not taking out of it more than the net profit. Ploughing back part of the profits to increase the capital is sound business indeed. To draw on capital for current consumption, " to mine land " means the starting downward movement in geometrical progression. To use an Iron and Steel Factory to produce pins and needles or a team of cycle-rickshaws for heavy transport would be as stupid as to neglect maintenance of vital machinery with lubrication and replacement of parts as they wear out. All these platitudes well understood in industry are equally applicable to the most important form of capital available, viz. land; and yet so few realize the need for applying the basic principles to the largest industry in this country.

Human population is increasing in geometrical progression. Large numbers are already consuming far less than what they require. Food production is also, no doubt, increasing by bringing more areas into cultivation and by increasing production per acre through better seed, manure, cultivation practices and controlled moisture. Technological advancement has been great and will continue to increase production significantly. Will the present enormous deficit be made up and the budget balanced in the future, not only on a world basis but in each area ? This has been exercising the minds of people somewhat intensely lately. Future technical advance is difficult to predict quantitatively but with increasing control over diseases, particularly of the epidemic variety — it is quite clear that the demand for food will increase inexorably. Artificial synthesis of the proteins, sugar and fats has not progressed and is nowhere near the economics of agriculture. Plant life, building food from the soil and sunlight, remains the basic provider of food directly, or through animal life. The ancient statement that essence (end product ?) of the earth is water, the essence of water plant, the essence of the plant man, still holds good. And as long as this is so our primary need is the soil. In countries, like India where there is comparatively little scope for much reclamation, low availability of cultivated land *per capita,* depleted soils giving poor production and the vast mass of the population living below the minimum levels of food considered necessary for healthy life, the intensity of the problem of making the best use of lands should be obvious to those who are prepared to think of it. Nor does this problem only concern the cultivator. All men eat and drink and food and water are equally the concern of all.

Land without water is as sterile as a word without meaning. Life, plant or animal, as we know it, cannot exist without water. Clouds bring water in the form of rain, hail or snow. Part of it is absorbed by the soil for use of plants and animals and the rest goes down the great rivers into the sea but the sun again evaporates it to form the clouds and completes the cycle. The supply from the cloud is not under control — notwithstanding piddling experiments to the contrary. The total average rainfall may be in excess or just what is required or less. Even where the rain meets the demand, its distribution during the season may be uneven creating temporary drought or flood. To store the water when it comes, by all

manner of methods and to use it in accordance with requirement is the ultimate aim of conservation of water. Disposal of excess water when the rain comes down in great intensity over a large area is the headache of engineers in charge of flood control. Running water wears down rocks and helps in the formation of soil. But water running without control, particularly in areas of soft soil exposed to beating rain by man, often runs away with the soil. " To make water walk instead of run " is the essence of soil and water conservation.

The best possible use of land and water for the permanent benefit of society is more urgent than any other problem. A survey of the present uses of different areas of lands for different purposes and their suitability for such purpose is the first stage. Soils differ in their inherent potential to grow more or less exacting crops and do best when laid out to the crop for which they are best fit. Even then depending on the varieties grown and the climatic condition, manuring and cultivation practices have to be adjusted to ensure optimum fertility year after year. This applies to all crops, forests, pastures, orchards. Location of industrial areas with an adequate green belt to supply foodgrains, vegetables, fruits, milk and meat is increasingly realized to be important in town and country planning. The ideal plan is very different from the actual and progressively changing over land use and cropping practices in the right direction require vision, persistent initiative, persuasive capacity and faith in the plan. The major part of the change in agricultural land has to be effected by the cultivating owner and where such change constitutes a departure from existing practices or economic standards, clear understanding must precede possibility of willing acceptance. And significant change over large areas can only be secured by a people's movement on the one hand, and an adequate policy and programme of work to secure better use of land and water on the other. The basic principles can be understood by all; in fact, if they cannot be understood, there is little chance of their wide acceptance.

The Availability of Phosphates in the Calcareous and Non-Calcareous Soils of North Bihar

by SHEONATH PRASAD

THE soils of Bihar mostly on the north of the river Ganga are roughly divided into two types — the calcareous and the non-calcareous types (FIG. 1). The former occurs in the semi-arid zones characterized by the rainfall 45-50 in. and the latter in the semi-humid zone with an average rainfall of 60-70 in. (FIG. 1A). There is a good deal of difference in texture and colour in the two soil types. The calcareous soils are generally light loam having chalky white appearance. The non-calcareous differ in texture from light loam to clay loam, and have dark grey or brown colour.

The problem of phosphate availability in the calcareous soils is of vital importance with respect to the fertilizer application since the common phosphatics do not respond well on account of the fixation due to

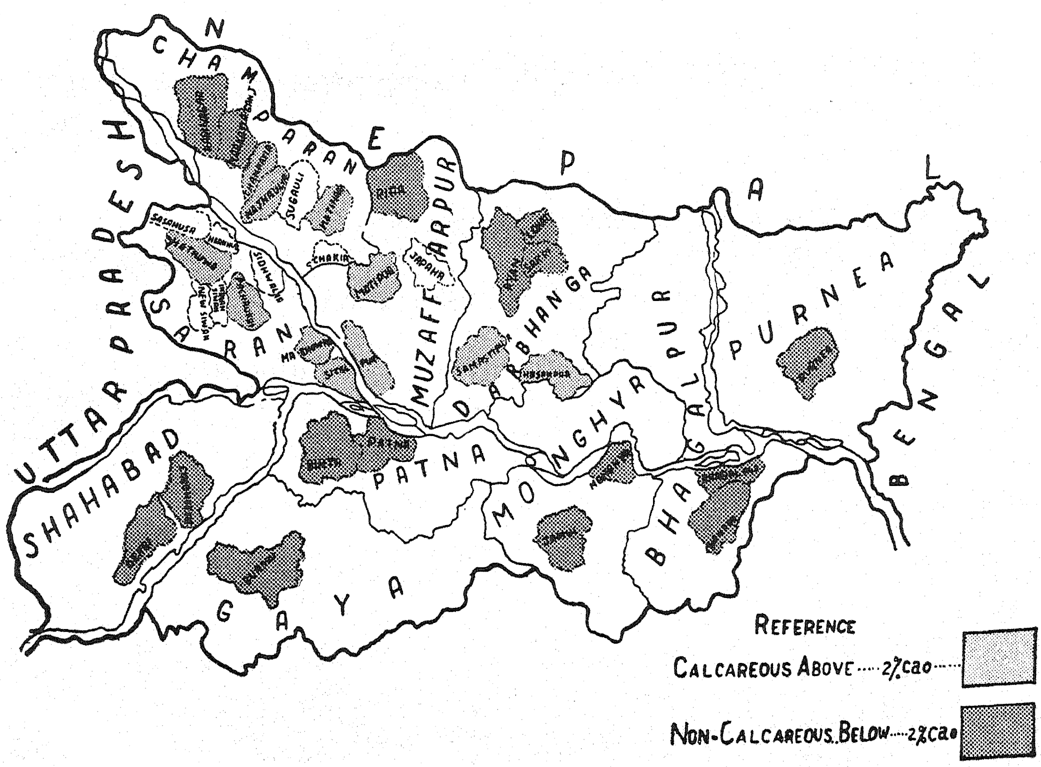

FIG. 1 — THE CALCAREOUS ZONE OF BIHAR

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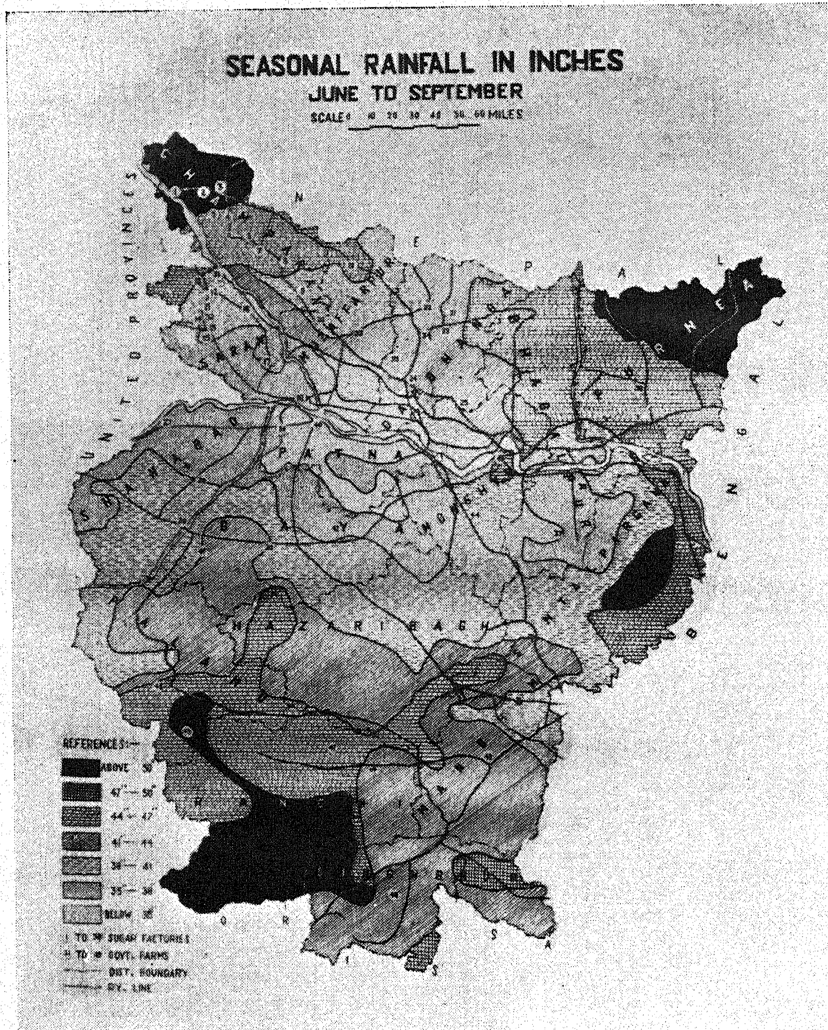

FIG. 1A — SEASONAL RAINFALL IN INCHES (June to September)

reversion of the soluble form into insoluble calcium compound.

It was, therefore, felt essential to assess the available phosphates in these soils by different methods and compare them each other with respect to their availability potential.

It will not be out of place to give a general review of the availability tests applicable to the soils in general and particularly to the phosphates, before a comparative study of the analysis of the available phosphates in the above two types of soils is taken up.

These tests are meant for finding available plant nutrients in soils. The major nutrients are N.P.K. Most of these tests are related to the above factors of plant growth. A few tests of micronutrients such as copper, boron, zinc, manganese and molybdenum have also been developed, but these are still not up to that stage where we can distinguish them into available and non-available form in the soil.

The tests may roughly be divided into the following heads:

1. Chemical (Conventional methods)
2. Biochemical
3. Biological
4. Agronomical

In the chemical tests soils are treated with dilute acids. Both inorganic as well as organic acids have been used, with the object of extracting available plant nutrients on the analogy of the root as the extractor of nutrient from the soil. Some of these tests need many hours' shaking and thus the time consumed for the completion of the analyses is much more than that desired for the quick advisory service. A few rapid tests have also been developed which consist of quickly shaking soils with the dilute acids after they are roughly measured in containers. The acids are buffered at suitable *p*H and the extract is tested colorimetrically. The methods are often not taken to be reliable but their validity is unquestionable if positive correlation is established with the crop rating.

The biochemical methods are carried out by growing test plants on soils and analysing the seedlings raised. The crop itself is said to be the best indicator of the deficiency in the soil. Rye seedlings were raised for a very long time for this purpose, but nowadays the feasibility of other test crops is not completely ruled out. Wheat, maize or lucerne are being gradually recognized as equally good test crops. The other biochemical method is the leaf or sap analyses for the plant nutrients. The methods are carried by sampling the leaf or plant sap on the field, and correlating the ingredients analysed with the crop yield.

The biological tests are based on the principle that the lower plant organisms need for their nutrition various inorganic elements such as nitrogen, phosphates, potassium, iron, calcium and sodium in addition to the micro-nutrients manganese, zinc, boron, molybdenum, cobalt, nickel, etc., and the deficiency of one of them is reflected on the growth of the lower plants or even the bacteria on the soil plaque can be measured and deficiency indicated quantitatively.

Historical Review

The Conventional Methods — These are the oldest tests adopted by the soil scientists. The classical investigation in search of the active elements in soils was first taken up by G. B. Daubney[1]. He showed that only a part of the total supply of plant nutrient elements in soils is active which term is nowadays used as available. The rest he said remained dormant in soils. Lawes and Gilbert[2] the pioneer agricultural scientists in Great Britain and founders of Rothamsted Agricultural Research Station in England were able to show that different plants took different amounts of nutrients from the same field. The theory current in those days was that the roots of the plants secrete acids which dissolve the nutrients in soils and make them available for plants. One of the earliest work in this direction appears to have been done by Dyer[3]. He used 1 per cent citric acid for extraction of phosphate and potassium and designed that quantity available for plants. This analytical procedure gained much ground in England and to some extent in Europe for a pretty long time. The solvent action of the strength of this acid was found to correlate positively with plant growth on some soil types. Wood and Berry[4] and Hall and Plyman[5] reported positive results. The method, however, was criticized later by Russel and Prescot[6] on the ground that there was no experimental evidence to support the root secretion theory and the solvent action of that secretion. A few German scientists developed identical type of method based on the solvent action of carbonic acid. The pioneer in that was Dircks[7-9].

Most of the above methods were applicable to phosphates and potassium. A few special methods for phosphates were also in vogue for a long time. These were based on dialysis, percolation, equilibrium and relative solubility.

J. W. Tidmore and his associates[10] are the main advocates of the dialysis method. They used collodian tubes as dialysers and extracted the soils by putting the tubes in water with the soil inside these tubes. The results obtained, however, lacked correlation with the plant growth.

P. L. Hibbard[11] used percolation method for testing available phosphates in soils. In the specially devised percolators he extracted phosphates with dilute acids by slowly allowing the acid to pass through the soil in the percolator. He claimed to have tried this method on hundreds of soils and proved its

efficiency on the ground that the action of acid is similar to plant in removing gradually the nutrient from the soil. Unfortunately he could not establish positive correlation of his method with field tests.

In the equilibrium test the soil and the extracting solution are brought in equilibrium by mixing the soil with the solution which is supposed to be of the same strength and potency as the soil moisture saturated with CO_2 in the pore space of the soil. This soil solution has got solvent effect on the soil and plant roots take their nutrient supply from the solution so formed in the interstices of the soil particles in equilibrium with the air. The solvent (liquid phase), the air (gaseous phase) and the soil (solid phase) are held in equilibrium in the most complicated manner and this very equilibrium is thought to be reached artificially. Most of the conventional methods described above and many of the rapid methods which will be described later belong to this group. It all depends on the nature and potency of the extracting solutions and soil-solution proportion, which will give a good correlation between results of analyses and crop yield. Naturally, different methods have been recommended for the different soil types and even for the different crops. There is not one panacea for all evils and " Hit and choose " methods have been followed by the workers. The position still remains unsettled though much has been strived at.

Limmermann[12] devised a method based on the relative concentration of phosphates in the two concentrations of the acid, one the strong acid and another comparatively weak one. This method also did not find favour because it could not show the benefit of its application in advisory work.

Von Wrangel[13] described the factors that are responsible for the supply of phosphates from soils to the growing plants. These are: (a) the kind of plant, (b) presence of calcium salts that limit the uptake of phosphates by the plants, (c) the effects of electrolytes and the organic substances in soil, (d) the reaction and the absorptive power of the medium in which the plant grows, (e) the action of microflora. It is essential in his opinion to know the time rate at which the soil will regain its original concentration of phosphates after it has been depleted by extraction with water or by growing plant. He considers the leaching effect by water to be the main principle involved in the availability of phosphate ion from soil. On that principle has been evolved an equation by him $a^2/a-b = x$, where a and b are the amounts of phosphates removed by water successively and x the degree of availability. He claims that his results obtained in this way are very well correlated with field and pot tests.

Biochemical Methods — This method as stated above consists in the estimation of the nutrients in leaves, chlorophyll cell sap or tissues for indication of the supply from the soil. Usually N.P.K. are estimated. There are two different lines of attack on the problem of the assessment of availability by biochemical methods. One is the estimation of nutrients removed from the soil in small pots when any indicator crop is grown on these soils for limited time. Most of the nutrients are absorbed in the early stage of plant growth and it is concluded that the analyses of the plant grown in the pots will give the idea of deficiency in measurable quantity. This method is widely tested by Neubauer[14] who is the originator of it. The other method is called " Foliar diagnosis " method, in which the leaf is sampled for analysis and the results correlated with yield. The classical researches on this has been done by Pierre Isodore[15]. He established the sensibility of the leaves to changes in environments. Ever since that time a series of research work have been published corroborating the validity of the technique for evaluation of plant nutrients in soil. There has been the criticism advanced on basis of physiological incompatibility and ion antagonism. But in midst of the criticism and counter arguments the trial on the test continues and the principle seems to hold ground on positive results with few exceptions. In recent years Lagatu[16], Maume[17], Lundegardh[18], and Thomas[19] have added more impetus to the applicability of this principle in practical agriculture by supplying more cogent and rational informations through ingeneous methods of interpretations. They seem to agree on the similarity of the physiological activities in the plant under similar medium of growth (soil) when the morphological factors are similar and the plant belongs to the same species and variety. Leaves being the laboratory of synthesis are said to be more appropriate part of the plant

but other parts, such as stock tissue or sap, are not absolutely ruled out.

Biological Tests — In the biological tests investigations have mostly been done on growth performance of the Azatobacter as indicative of the phosphate deficiency. Cunninghamella has also been tried. The outstanding work in this direction has been done by Greene[20], Stewart and others[21], and Mehilch[22]. At Long Ashton Research Station Nicholas[23] has carried extensive investigations on *Aspergillus niger* (M) to indicate its effectiveness for measuring deficiency of the trace elements such as manganese and molybdenum. The results have not been of much practical value since they are tried on growth of fungi and the analogy has been carried too far on higher plants. Correlations with field and pot tests are still not found positive in many cases.

Agronomical Tests — Two most important procedures are adopted in this type of investigation. One is the pot test, very commonly known as the Misterlisch[24] test and the other is the common field trial. The origin of the pot test is from the sigmoid curves obtained by Helriegell and later by Weissmann[25] who have shown that keeping all other factors constant if the factor limiting the crop growth is proportionately increased in soil, such increase will give correlation with the yield which can be expressed by a curve of the sigmoid type. The mathematical expression to this curve was first given by Misterlisch (ibid.) who enunciated the intricate relationship of the plant soil system on the basis that the increase in the yield of crop produced by the unit increment of the lacking factor is proportional to the decrement from the maxima. This is given by the equation $dy/dx = (A-y)c$ wherein the y = the yield obtained on the presence of the x amount of the factor, and A is the maximum yield obtained if the factor is in excess and c is the constant. The other test called field test bases its generalization on the principle of well known law of response on application of the nutrient which is in deficiency in soil. The response can be statistically calculated. This test is applied finally on positive results obtained by the above deficiency tests in laboratories or in pot houses.

The Chemical Characters of the Two Soil Types — Long past it has been recognized that the calcareous soil is that which contains high percentage of calcium carbonate. In general these soils occur in arid region but it is doubtful if the aridity is responsible for the high percentage of calcium carbonate in the soils of North Bihar wherein at places the percentage of calcium carbonate is as high as thirty. Since the climatic conditions in the region are not completely identifiable with that of true arid zones, some adventitious sources of calcium carbonate either by biological means of distribution through shell multiplication or transportation of dolomitic clay from the Himalayan region in the North may be ascribed to the causes of high calcium carbonate accumulation. One fact may be borne in mind that the calcareous region is spread mostly on the two sides of the river Gandak which has become the line of demarcation of the political division of two districts of Saran and Champaran in Bihar. This distribution is found from its appearance on the planes in the north down to its estuary where it joins river Ganga.

Fraps[25a] recognized the differences in the two types of soils. He named one as 'Calcareous' and another as 'Sileceous'. He also defined different availability tests, such as 'Chemical', 'Positional', 'Weathering', and 'Physiological'. Burd[25b] later clarified the differences between 'Calcareous' and 'Non-calcareous' soils with respect to the amount of calcium carbonate, exchangeable calcium, and hydrated oxides of alumina and iron. The calcium carbonate also created a lot of difference in *p*H. In the North Bihar two zones are clearly differentiated by the concentration of the calcium carbonate and the exchangeable calcium, which is shown in Table 2 below. In Table 1 is given the correlation of *p*H with the R.C.M. calcium (Morgan's test) which almost appears to be a linear relation from *p*H 6 to *p*H 8 (FIG. 2). It is clear that the major variations in *p*H in these soils are due to the presence of calcium.

In Table 2 is given the chemical characters of the two soil types the availability of which with respect to phosphates is under investigation. The analysis has been done by HCl extraction method as recommended by A.O.A.C.

It is to be concluded from the above analyses that the calcareous soils contain lower organic N and also soluble N such

TABLE 1 — SHOWING CORRELATION OF R.C.M. CALCIUM AND *p*H IN SOILS OF LOHAT RESERVE AREA (Fig. 2)

Sl. No.	*p*H	Mean R.C.M. CaO in lb./acre	Number of readings
1	6·0	665	14
2	6·2	702	22
3	6·4	871	24
4	6·5	721	8
5	6·6	752	24
6	6·8	873	46
7	7·0	1009	40
8	7·2	1434	26
9	7·4	1568	39
10	7·6	1975	31
11	8·0	1963	12

TABLE 2 — ANALYSIS OF CALCAREOUS AND NON-CALCAREOUS SOILS

Ingredients analysed	Non-calcareous soil	Calcareous soil
Percentage of moisture	1·7725	0·5475
Percentage of loss on ignition	2·5605	1·8725
Soluble silica	0·0591	0·0577
Insoluble silica	84·2148	53·3432
Percentage of sesqui-oxides	7·8020	7·9583
Percentage of calcium oxide	1·5252	19·0039
Percentage of magnesium oxide	0·2875	0·6843
Percentage of potassium oxide	0·5489	0·5919
Percentage of sulphates	Traces	nil
Percentage of carbon dioxide	1·0500	14·9300
Percentage of sodium oxide	0·0123	0·0105
Percentage of total phosphates	0·0700	0·0800
Me equiv. exch. Ca	7·0000	8·5000
Percentage of Chlorides	0·0021	0·0014
Percentage of org. nitrogen	0·0826	0·0595
Percentage of amm. nitrogen	0·0037	0·0017
Percentage of nitric nitrogen	0·0041	0·0035
*p*H reading	6·5-7·0	8·5-9·0
Percentage of sand	46·7000	28·0300
Percentage of silt	35·4000	59·5350
Percentage of clay	17·9000	12·4350

as NH_3 and NO_3 than those in the non-calacareous soils. The calcium in the calcareous soils is up to 19 per cent as CaO as compared to 1·5 per cent in the non-calcareous type. Total phosphates do not vary very much.

Determination of Available Phosphates by Chemical Methods — In the determination of the available phosphates of the calcareous and non-calcareous soils of Bihar water soluble phosphates, citric soluble phosphates, Truog's available phosphates modified for the calcareous soils and Morgan's R.C.M. method were followed.

The water soluble phosphates were estimated by shaking the soil for 8 hours with water in the proportion of 1: 5, and analysing the extract according to Denige's method. Citric soluble method was followed according to the well-known procedure recommended by Dyer (ibid.). Available phosphate was analysed in the non-calcareous soils according to the recommendations by Truog[23]. In the calcareous soils the method was modified as recommended by Thornton[27], since the use of sulphuric acid both in the extracting as well as colouring reagent interfered with the calcium carbonate present in the soil in excess. The sulphate was precipitated as calcium sulphate and colorimetric determination was not possible.

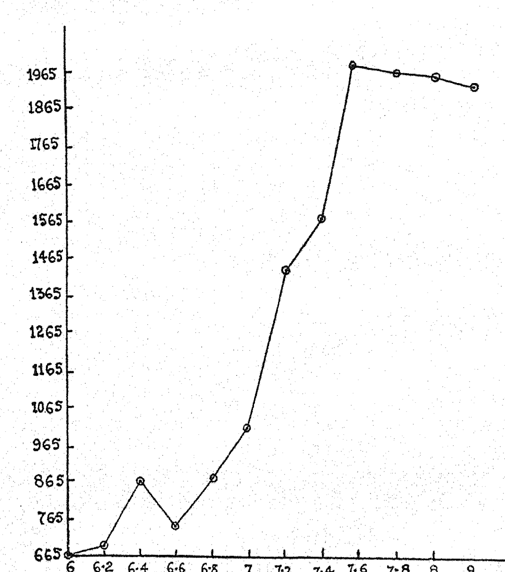

Fig. 2 — Showing *p*H and R.C.M. calcium in soils of Bihar

The rapid method technique followed was that recommended by Morgan[28].

The results are presented in Table 3 below.

It is evident from the above results that in the non-calcareous as well as calcareous soils the water soluble phosphates are considerably lower than the acid soluble phosphates, but the same when compared as between the types seem to indicate very low extraction capacity in the calcareous soils. Citric soluble phosphates are lower than the Truog's acid soluble and here also within the soil types both the methods indicate higher extraction capacity in the non-calcareous soils. Also the Morgan's R.C.M. technique has given higher values for the non-calcareous soils.

Determination of Available Phosphates by Biochemical Method — The method followed in this case was the same as described by Neubauer (ibid.). 800 gm. of crushed and sieved soils of the two types were taken separately in parafined earthen pots of 6 in. diam. and 2 in. height. 80 cc. of distilled water was added to the pots containing the soils and kept for 24 hours to reach saturation up to 10 per cent moisture. Two varieties of

TABLE 3 — SHOWING THE RESULTS OF THE ANALYSES OF THE AVAILABLE PHOSPHATES

Sl. No.	Non-calcareous				Calcareous			
	Water solution P_2O_5	Dyer's citric P_2O_5 mgm., %	Truog's available P_2O_5 H_2SO_4 ext. mgm., %	Morgan's lb. per acre	Water soluble P_2O_5 p.p.m.	Dyer's citric sol. mgm., %	Truog's available P_2O_5 HCl. ext. orgams., %	Morgan's lb. per acre
1	1·2	26	90	50	0·6	5	20	10
2	1·5	22	60	100	0·8	2	20	10
3	4·9	30	120	50	1·1	2	30	10
4	5·0	20	80	100	0·6	10	50	10
5	4·8	40	75	25	1·0	5	20	Trace
6	2·9	31	90	25	1·3	10	20	10
7	2·8	35	58	50	1·6	10	20	Trace
8	5·3	35	55	100	1·1	10	40	10
9	7·8	40	78	25	0·0	5	40	10
10	1·8	20	80	25	0·2	5	20	10
11	1·9	20	48	50	0·9	6	20	Trace
12	4·9	20	34	100	0·1	2	30	10
13	7·1	30	58	50	0·2	6	50	10
14	1·2	10	62	50	0·3	2	20	10
15	5·2	30	78	50	0·5	5	40	10
16	6·2	40	56	50	0·6	6	50	10
17	7·2	40	49	50	0·5	10	50	10
18	8·2	50	65	100	0·8	5	50	10
19	3·5	10	33	50	0·2	4	20	10
20	3·2	8	40	50	0·8	4	20	10
21	9·8	50	100	100	1·1	10	50	10
22	1·2	10	20	10	0·5	Trace	20	10
23	5·6	20	30	50	0·6	5	30	10
24	4·2	20	50	50	0·3	4	25	10
25	1·2	10	20	10	0·1	Trace	10	10
26	3·5	40	30	10	0·5	4	25	10

wheat Pusa 52 and C 518 were sown — each in 4 separate pots. Harvesting was done after a period of 5 weeks. Leaf and stock were analysed separately from the roots. Average results are given in Table 4.

It can be concluded from the above results that in both varieties of wheat the calcareous soil has behaved quite differently from the non-calcareous. In the former the available phosphates taken up by the plant is far less than in the latter.

Determination of Available Phosphates by Biological Method — In application of this method on the calcareous soil type azatobacter plaque technique was followed. Soil pastes called plaque are made and incubated in petri dishes at 37°C. After about 48 hours or so the azatobacter colonies in dark small circles appear. The higher the available phosphates, the greater the number of colonies.

Following this method observations were taken on the development of colonies in the calcareous soils with different phosphatic fertilizers. The results are given in Table 5.

It appears from the above results that the calcareous soils suffer from phosphate deficiency since the colonies did not appear unless the phosphatics were added. Of the different phosphates sodium hydrogen phosphate showed best results.

Water Soluble Phosphates and Their Correlation with total (HCl extract) Phosphates — Investigations carried by earlier workers indicate that the water soluble phosphates in soil solutions are very small in magnitude of concentrations. Burd and Martin[29] and Pierre and Parker[30] have stated that they are usually lower than even 1 P.P.M. Water soluble phosphates are not phosphates of any particular cation dissolved in water. They are phosphates held in equilibrium with insoluble phosphates either in colloidal form or absorbed form.

Interesting correlation studies between total and water soluble phosphates were done on some of the soils of the calcareous and non-calcareous regions of North Bihar, collected during the soil survey of the different sugar factory reserved areas situated in the two different zones.

In Table 6 below is given the percentage of total and water soluble phosphates of surface samples 0 in. to 12 in. collected from four reserved areas — two in calcareous and two in non-calcareous.

TABLE 4 — SHOWING NEUBAUER ANALYSES OF PHOSPHATES IN WHEAT

Sl. No.	Soil type	Variety of wheat sown	Available P_2O_5 lb./acre	Total P_2O_5 utilized by the plant gm. %		
				Leaf & stock	Root	Total
1	Non-calcareous light soil	Pusa 52	100	0·0052	0·0029	0·0081
2	do	C 518	100	0·0038	0·0035	0·0073
3	Calcareous light soil	Pusa 52	10	0·0010	0·0015	0·0025
4	do	C 518	10	0·0009	0·0018	0·0027

TABLE 5 — SHOWING THE EFFECT OF DIFFERENT FERTILIZERS ON THE GROWTH OF AZATOBACTER COLONIES IN THE CALCAREOUS SOILS

Sl. No.	Treatment	Observations	No. of colonies average of 6 observations
1	Control: Soil + water + starch	No colonies	nil
2	Soil + Na_2HPO_4 + water + starch	Colonies abundant, brown and black dots	55
3	Soil + K_3PO_4 + water + starch	Colonies appeared in large number	Counting not possible
4	Soil + KH_2PO_4 + water + starch	Colonies appeared sparse	40
5	Soil + (NH)HP_4 + water + starch	Fungus growth, nitrogen suppresses the growth of azatobacter	nil

TABLE 6 — TOTAL AND WATER SOLUBLE PHOSPHATES (Figs. 3, 4, 5 & 6)

Sl. No.	Reserved area							
	Hasanpur — calcareous		Sitalpur — calcareous		Lohat — non-calcareous		Sakri — non-calcareous	
	Total P_2O_5, % $\times 10^{-3}$	Water sol. P. P.P.M. $\times 10^{-1}$	Total P_2O_5, % $\times 10^{-3}$	Water sol. P_2O_5, % $\times 10^{-1}$	Total P_2O_5, % $\times 10^{-3}$	Water sol. P. P.P.M. $\times 10^{-1}$	Total P_2O_5, % $\times 10^{-3}$	Water sol. P. P.P.M. $\times 10^{-1}$
1	97	22	530	23	68	nil	131	14
2	96	30	163	27	18	15	228	2
3	73	33	256	32	43	5	150	5
4	83	38	—	—	580	49	295	20
5	96	51	170	25	571	50	83	7
6	111	24	151	31	63	6	79	10
7	129	27	60	9	46	12	97	13
8	103	13	128	5	91	11	77	18
9	108	11	75	8	521	48	71	17
10	103	23	40	13	421	29	83	30
11	96	7	—	—	69	28	93	32
12	100	26	96	13	73	15	80	20
13	103	14	—	—	97	53	97	19
14	99	11	66	7	43	3	95	24
15	52	9	255	28	231	78	127	28
16	112	10	51	15	485	18	76	7
17	105	16	—	—	109	19	83	14
18	116	20	—	—	85	49	67	10
19	120	18	224	254	50	5	75	16
20	132	11	65	16	59	71	95	13
21	119	10	—	—	150	25	—	—
22	106	8	77	12	175	30	—	—
23	114	14	—	—	400	40	—	—
24	108	19	—	—	450	48	—	—
25	119	12	50	18	—	—	—	—
26	71	17	—	—	—	—	—	—
27	106	6	—	—	—	—	—	—
28	101	14	48	14	—	—	—	—
29	94	16	55	36	—	—	—	—
30	99	8	89	28	—	—	—	—
31	105	11	—	—	—	—	—	—
32	103	16	—	—	—	—	—	—
33	120	11	—	—	—	—	—	—
34	94	18	—	—	—	—	—	—

TABLE 7 — SHOWING CORRELATION BETWEEN TOTAL AND WATER SOLUBLE PHOSPHATES IN CALCAREOUS AND NON-CALCAREOUS SOILS OF NORTH BIHAR

Sl. No.	Calcareous				Non-calcareous			
	Reserved area	*p*H	CaO % average	Coefficient of corre-lation	Reserved area	*p*H	CaO % average	Coefficient of corre-lation
1	Hasanpur	8·0	5·0	0·1996	Lohat	7·5	0·75	0·4067
2	Sitalpur	8·4	12·2	0·0383	Sakri	7·3	0·80	0·4476

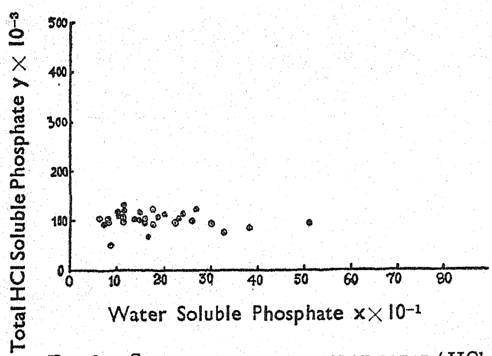

FIG. 3 — SHOWING CORRELATION OF TOTAL (HCl Extract) PHOSPHATE WITH WATER SOLUBLE PHOSPHATE IN RESERVED AREA, HASANPUR (Soil Zone — Calcareous)

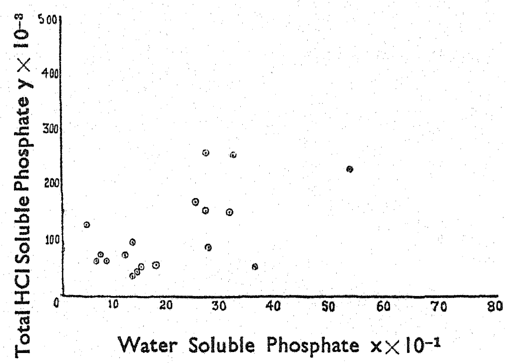

FIG. 5 — SHOWING CORRELATION OF TOTAL (HCl Extract) PHOSPHATE WITH WATER SOLUBLE PHOSPHATE IN LOHAT RESERVED AREA (Soil Zone — Non-Calcareous)

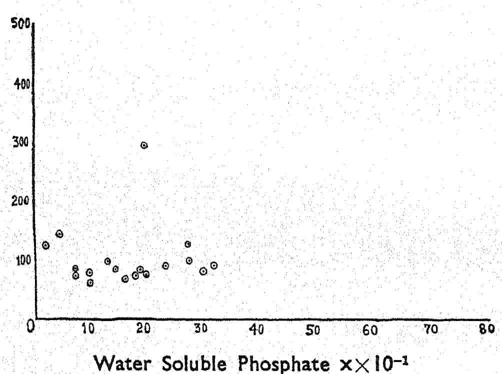

FIG. 4 — SHOWING CORRELATION OF TOTAL (HCl Extract) PHOSPHATE WITH WATER SOLUBLE PHOSPHATE IN SITALPUR RESERVED AREA (Soil Zone — Calcareous)

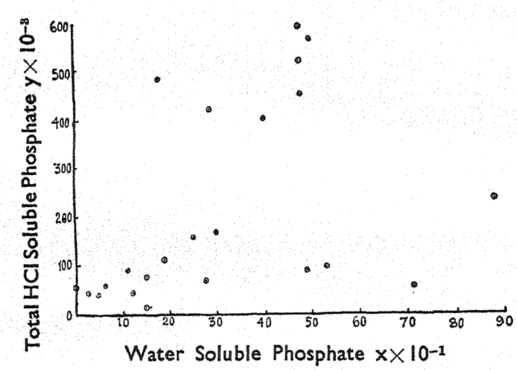

FIG. 6 — SHOWING CORRELATION OF TOTAL (HCl Extract) PHOSPHATE WITH WATER SOLUBLE PHOSPHATE IN SAKRI RESERVED AREA (Soil Zone — Non-Calcareous)

Based on these observations the coefficient of correlation and regression equations of the two values separately for each area have been calculated. In Table 7 is given the correlation coefficient obtained in the different areas.

The study of the correlations show positive significance in the non-calcareous zones and insignificant results were obtained in the calcareous zones (FIGS. 3, 4, 5 & 6).

The following regression equations were calculated for samples in different areas:

If $x =$ Total phosphates
$y =$ Water soluble phosphates
Then
In calcareous area:

Hasanpur: $y = 29{\cdot}90 - 0{\cdot}121x$. Regression coefficient $= -0{\cdot}121$
Sitalpur: $y = 15{\cdot}33 + 0{\cdot}006x$. Regression coefficient $= +0{\cdot}006$

In non-calcareous area

Lohat: $y = 15{\cdot}14 + 0{\cdot}042x$. Regression coefficient $= +0{\cdot}042$
Sakri: $y = 19{\cdot}05 + 0{\cdot}051x$. Regression coefficient $= +0{\cdot}051$

From above it is apparent that the calcareous zones of North Bihar fix up phosphates considerably. Not only the water soluble phosphates poorly correlate with the total in these areas but the organic phosphates also in these areas are comparatively lower in concentration as is shown in Table 8.

In an earlier publication Khanna, Prasad and Bhattacharya[33] concluded that the total phosphates and Truog's available phosphates correlate positively in the non-calcareous zones of North Bihar, but all our attempts to obtain positive correlation in the calcareous region have failed.

From the fact that neither the water soluble nor the acid soluble phosphates have positive correlation with the total, in the calcareous zones, stronger evidence is obtained of the presence of hydroxy apatite $[Ca_{10}(PO_4)_6(OH)]$ — an insoluble compound in addition to carbonato apatite $[Ca_{10}(PO_4)CO_3]$ which is sparingly soluble — in these soils.

Incidentally leaching of the calcium and phosphates in the two areas was also studied by analysing calcium and phosphates in the soils of the horizons of the exposed profiles during the survey.

About 151 profiles were studied in the calcareous and non-calcareous zones. The estimations of calcium carbonate and total phosphates in horizons from surface to the bottom 6 ft. show that in the calcareous zones, the incidence of leaching of the calcium is comparatively greater than in the non-calcareous zone. The percentages of profiles in which this has been observed in the two zones are given in Table 9.

The phosphates in the calcareous zone, however, were retained in majority of the profiles compared to that in the non-calcareous zone.

Thus it is clear that the non-calcareous area also suffers a good deal for want of phosphates due to leaching and instances of pockets of very low *p*H (*p*H5) have also been observed in this area, wherein it is to be concluded that there is considerable possibility of the phosphates fixed up in these areas as well due to iron and aluminium.

Conclusion

1. The area of North Bihar can be demarcated distinctly in two zones, one the calcareous and the other the non-calcareous.

TABLE 8 — SHOWING ORGANIC AND INORGANIC PHOSPHATES AND THEIR RATIO IN TWO AREAS

Sl. No.	Calcareous soils			Non-calcareous soils		
	Inorganic P_2O_5, %	Organic P_2O_5, %	Organic P_2O_5 of the total, %	Inorganic P_2O_5, %	Organic P_2O_5, %	Organic P_2O_5 of the total, %
1	0·0750	0·0212	28·1	0·0820	0·0163	19·8
2	0·0650	0·0190	29·1	0·0890	0·0170	19·1
3	0·0780	0·0253	32·3	0·0920	0·0050	5·3
4	0·0850	0·0278	32·5	0·0880	0·0100	11·3
5	0·0620	0·0210	33·8	0·0758	0·0110	14·5
6	0·0540	0·0220	40·7	0·0821	0·0120	14·6
7	0·0720	0·0290	40·2	0·0780	0·0220	28·2

TABLE 9 — SHOWING LEACHING OF CALCIUM IN CALCAREOUS AND NON-CALCAREOUS ZONES

Calcareous zones			Non-calcareous zones		
Number of profiles exposed	Number of profiles leached	Profiles leached, %	Number of profiles exposed	Number of profiles leached	Profiles leached, %
110	71	66·4	47	29	61·7

2. Study of the availability of the phosphates estimated by different methods and also correlation coefficient of the water soluble and total phosphates in the soils of the two areas indicate considerable deficiency of this element in the calcareous as compared to non-calcareous soils.

3. Considerable conservation of the phosphates in the calcareous soils due to the nature of the compound made insoluble in these areas on account of the presence of calcium carbonate in abundance is noticed in spite of leaching due to rainfall and irrigational practices.

4. It is, however, not safe to conclude that the non-calcareous zone does not suffer any deficiency of phosphates since the effect of leaching is derogatory to the accumulation of phosphate in these areas and on account of high precipitation range acidity is going to develop which is harmful for phosphate availability due to fixation by iron and aluminium.

Acknowledgement

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Bunding of Deep Black Soils of Bombay State

by D. A. GADKARY & M. S. V. RAMA RAO

FROM the soil classification point of view, the State of Bombay can be divided into 7 zones.

Northern Gujarat, comprising of districts of Ahmedabad and Kaira, forms part of the great plains of Northern and Central India. The soil is deep and alluvial, varying from drift sand in the north to rich loam in parts of Kaira. Southern Gujarat soils are essentially alluvial and the alluvium resembles the black cotton soil in colour, texture and other characteristics.

The Bombay-Deccan comprises of 3 different types of country. Khandesh contains rich and deep black cotton soil, the *ghat* region comprises mostly of rock or red shallow soil fully eroded. The area to the Eastern Ghat region, which we may call the 'Desh', comprises of coarse and shallow soils on the ridges and rich and deep soil in the valleys. Some of these deep soils are black in colour and texture.

The Karnatak contains soils derived from the Deccan Trap, quartzites and gneisses of the Kaladgi series and other metamorphic rocks of the South. On the river banks the soils are generally deep and clayey.

The soil of the Konkan comprising of the coastal districts of North Kanara, Ratnagiri and Kolaba are mostly laterite in origin and are generally shallow and poor.

A map is enclosed which shows the principal distribution of soils in the Bombay State, rainfall distribution and the scarcity zones.

The total cropped area of the Bombay State is 470 lakh acres.

Out of the above 470 lakh acres which requires soil and moisture conservation measures, nearly 33·50 lakh acres comprise of deep black soil areas.

Basing our classification within the scarcity areas of the State of Bombay, at least three different types of deep black soils can be found, all of which are derived from different parent rocks. When the thickness of the soil layer is moderate, say from one to two feet, no great difference in behaviours is noticeable, but when the thickness is considerable, the reactions of the three types are different.

The first type of black soil is the deep black soil derived from the Deccan trap and is found in the districts of Poona, Ahmednagar, Sholapur and Satara and the northern part of Bijapur and north-western part of Belgaum.

The second type of deep black soil is found in parts of Belgaum, Dharwar and Bijapur, and is derived from the transition rocks of those districts like the quartzites and sandstones.

The third type owes its origin to granites and gneisses and is found in Belgaum and Dharwar districts.

The essential characteristics of all the types are:

(a) the soils are deep, black in colour, crack heavily in the summer months and cake during the rainy season;
(b) the soils are mostly clayey, dispersible, and structurally unstable and alkaline in reaction;
(c) generally the Ca/Na ratio is high;
(d) the drainage as well as the infiltration capacity of the soil is very poor. As soon as the first rains come, the surface soil melts and forms a barrier for further infiltration of rain-water; and
(e) the erodibility of the soils is high.

The second type of deep black soil (derived from transitionary rocks) contains less clay and silt and more coarse fractions, like sand. The third type (derived from granites and gneisses) contains a greater proportion of the coarse grained fractions as compared with the deep black soil from trap.

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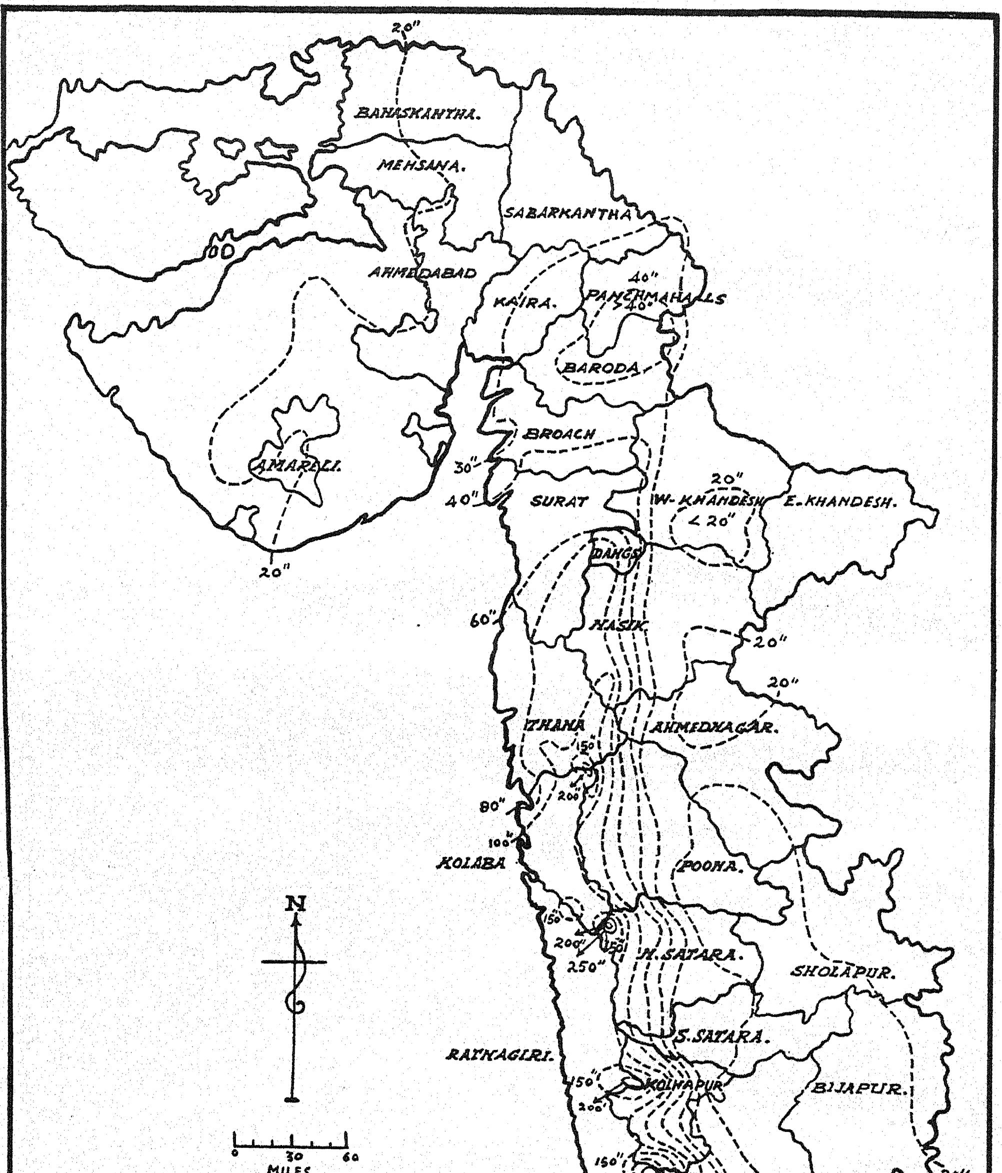

BANASKANTHA.
MEHSANA.
SABARKANTHA
AHMEDABAD
KAIRA.
PANCHMAHALLS
BARODA
BROACH
AMARELI.
SURAT
W-KHANDESH
E.KHANDESH.
DANGS
NASIK
THANA
AHMEDNAGAR.
KOLABA
POONA.
N.SATARA.
SHOLAPUR.
S.SATARA.
RATNAGIRI.
KOLHAPUR
BIJAPUR.
BELGAUM.
DHARWAR.
KARWAR
N
MILES.
MAP SHOWING ISOHYETS (POINTS of EQUAL RAINFALL) in
BOMBAY-STATE
M. I. BORGES.
INFORMATION FROM THE STATISTICAL ATLAS OF THE BOMBAY STATE.
CHECKED BY:-S.S.JADHAV

FIG. 1

In the State of Bombay we have been constructing 'bunds' for the past 12-13 years and nearly 13·2 lakh acres of land have been bunded as a soil-cum-moisture conservation measure. It may be said generally that bunds in deep black soil areas have been more or less a complete failure as bunds settle heavily, crack badly and often breach. On account of the poor angle of repose bearing power while wet, the land surface develops gullies during the rainy season. The poor drainage gives rise to long stagnation of water against the contour bunds, the stability of which is always in danger due to collapsing of sides. In these areas murum is not available near by to case the bund with, nor will grass or other vegetation grow easily on deep black soil embankments. *Hariali* or *lona* will grow but is viewed as a pest by the farmers. Government have, therefore, abandoned the construction of bunds in deep black soils until a suitable technique is evolved. Thus, it is evident that there is a large territory coming under the deep black soils which have been precluded from the benefits of large-scale bunding till the evolution of a suitable technique for the same. It is, therefore, considered essential and expedient to carry out necessary experimental and research work on bunding in deep black soil areas. Accordingly, the Director of Agriculture, Bombay State, prepared a scheme estimated to cost about 4·7 lakhs of rupees to carry out the necessary research work in connection with the construction of suitable types of bunds in deep black soil areas. The scheme envisages carrying out each research work in 4 blocks of 400 acres in each of the four regions of (1) Gujarat, (2) Khandesh, (3) Deccan, and (4) Karnatak, aggregating a total area of 1,600 acres. Research work will cover a period of 5 years.

Out of the four blocks trustees of Sir Cusrow Wadia Trust Fund have been kind enough to allot the necessary funds for one block. This is situated at Honmurgi in Sholapur district in the Deccan region. Plans and estimates for this work are under way and work is likely to be started in March-April 1955. Similar sanction for two more blocks suggested to be situated in Gujarat and Karnatak regions are expected shortly.

The scheme is designed to study the following on the statistically laid out large-scale plots so as to get the maximum amount of information of practical value in a minimum period of years:

(1) Trial of different types of bunds or terraces suitable to the erodible nature of the soils and the type of construction material available on the site.
(2) Agronomic practices to conserve moisture and check soil erosion.
(3) Stabilization of terraces and water courses by using suitable grass material.
(4) Studies and measurements of intensities of rainfall, runoff and erosion.
(5) Soil studies with reference to morphology, colloid contents, mechanical constituents and soil structure with a view to correlating soil properties and erosion control measures.

Thus in the 420 acres block at Honmurgi, the following are the details of the various experiments:

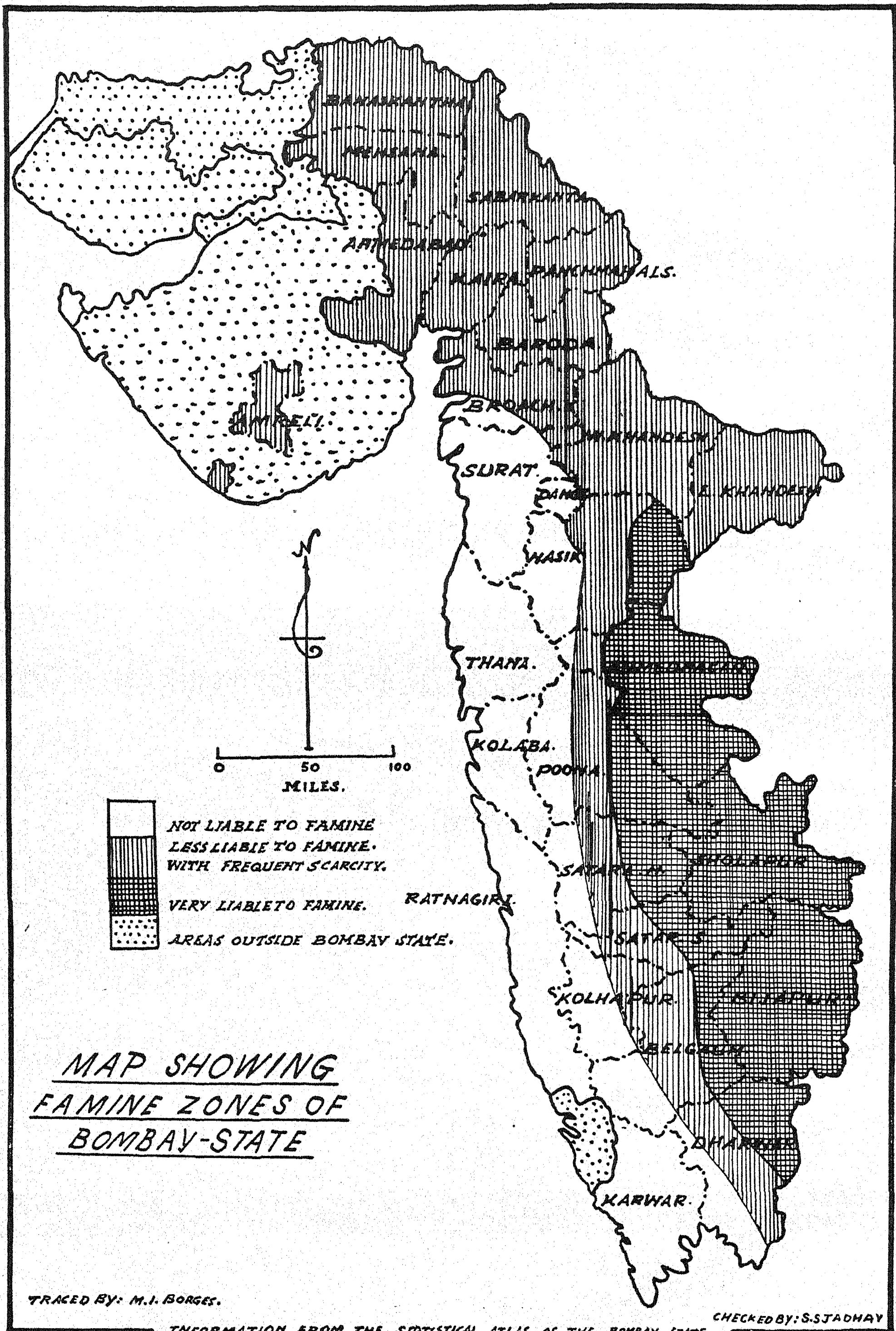
1. It is suggested that we should try trapezoidal bunds having sections of 16·00, 24·00 and 28·50 sq. ft. at vertical intervals of 2·5, 3·5 and 4·5 ft. The average ground slope of the proposed area at Honmurgi is 0·8 per cent.

	16·00 sq. ft.	24·00 sq. ft.	28·50 sq. ft.
Top width	1·75′	2′	2′
Side slope	1·5 : 1	2 : 1	2 : 1 D.S. & 3 : 1 U.S.
Height	2·75′	3′	3′
Area of section	16·00 sq. ft.	24·00 sq. ft.	28·50 sq. ft.

Bunds below 16·00 sq. ft. Section have failed in the past and bund having a Section above 28·50 sq. ft. will become very costly and the space lost under the bund will be a heavy percentage of the area to be improved. Thus it is suggested that we should restrict our selection only to the above 3 types.

Suitable types of outlets will also be provided, e.g. stone, grass and pipe outlets.

2. Some 8 years ago broad-based terraces having base widths of 18 to 24 ft. and central height of 18 to 24 in. were tried in cultivators' land at various places aggregating in all to 2,000 acres. Cultivation was allowed over the top of terraces. In due course the terraces went on eroding and eroding due to natural wear and tear and the cultivation by local farmers induced erosion, formation of gullies and breaches. All the above terraces were of absorption type and no outlets were constructed.


MAP SHOWING
FAMINE ZONES OF
BOMBAY-STATE
NOT LIABLE TO FAMINE
LESS LIABLE TO FAMINE.
WITH FREQUENT SCARCITY.
VERY LIABLE TO FAMINE.
AREAS OUTSIDE BOMBAY STATE.
N
0
50
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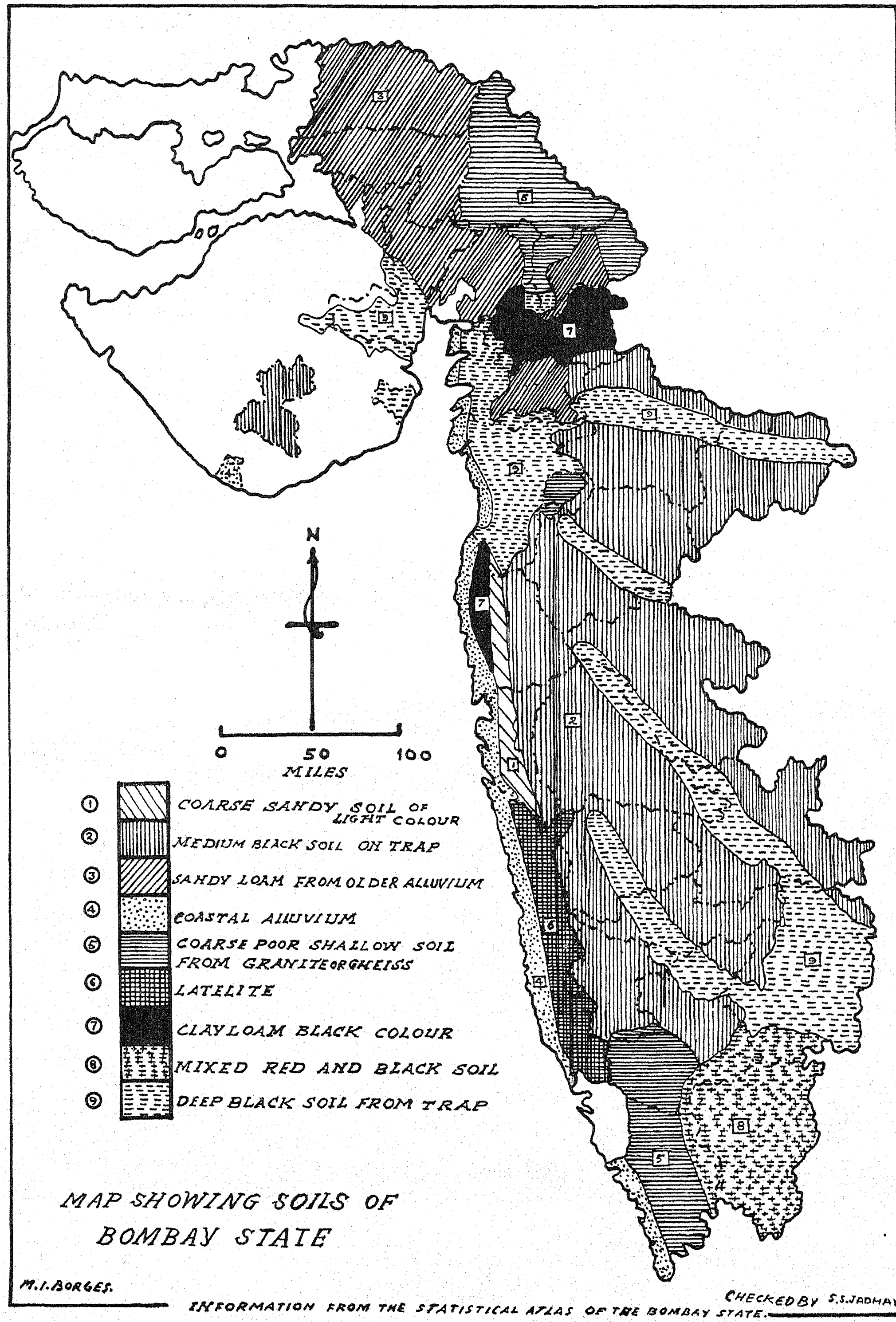
MILES.
AHMEDABAD
KAIRA
PANCHMAHALS.
BARODA
BROACH
AMRELI
SURAT.
DANGS
E. KHANDESH
NASIK
THANA.
KOLABA.
POONA
SHOLAPUR
SATARA N.
SATARA S.
RATNAGIRI.
KOLHAPUR.
BELGAUM
KARWAR.
TRACED BY: M.I. BORGES.
CHECKED BY: S.S.JADHAV
INFORMATION FROM THE STATISTICAL ATLAS OF THE BOMBAY STATE.

FIG. 2



N
0 50 100
MILES
① COARSE SANDY SOIL OF LIGHT COLOUR
② MEDIUM BLACK SOIL ON TRAP
③ SANDY LOAM FROM OLDER ALLUVIUM
④ COASTAL ALLUVIUM
⑤ COARSE POOR SHALLOW SOIL FROM GRANITE OR GNEISS
⑥ LATELITE
⑦ CLAYLOAM BLACK COLOUR
⑧ MIXED RED AND BLACK SOIL
⑨ DEEP BLACK SOIL FROM TRAP
MAP SHOWING SOILS OF BOMBAY STATE
M. I. BORGES.
CHECKED BY S. S. JADHAV
INFORMATION FROM THE STATISTICAL ATLAS OF THE BOMBAY STATE.

FIG. 3

It is now suggested to try 18 in. high terrace having suitable outlets, disallowing cultivation on the terrace top in one series and encouraging growth of grass over the terraces or planting suitable grasses and in another series allowing cultivation. Experience has shown that a falling contour terrace gets silted up too soon and causes gullying and erodes the front face of the terrace. The suggested terrace will be of 'absorption' type, as these works are in the scarcity zone and the idea is to impound as much rainfall as possible. The 18 in. high terraces get into disrepair too soon and increase cost of maintenance.

3. At the Sholapur Research Station suitable 'strip-cropping' methods are evolved for *kharif* crops and it is found difficult to have a suitable practice for *rabi* crops. Therefore, one plot is suggested entirely for contour cultivation. The idea is to see the benefit that is going to accrue without any mechanical structures and thus minimize cost of the soil-cum-moisture conservation measures.

Other items, like observation of rainfall and runoff intensities, studies with reference to morphology, colloid contents, etc., will be carried out. All the plots will be selected by randomization and crop yields under various practices will be observed, spread over a period of 5 years. It is expected that the above studies will give sufficient information to evolve a suitable and at the same time a cheap technique over the extensive black soil tract in Bombay State, which area is at present tabooed for undertaking any bunding work.

Reclamation of Kotar Lands

by D. A. GADKARY & M. S. V. RAMA RAO

KOTARS are deep gullies and their formation indicates advanced stage of gully erosion. They are noted for their enormous size and depth, the latter varying from 60 to 100 ft. with almost vertical sides. They are found in many parts of the State of Bombay on the banks of rivers, e.g. on banks of river Tapti in Khandesh, rivers Krishna and Bhima in parts of Deccan and Tungabhadra in Karnatak and to a greater extent on banks of Gujarat rivers. They are a menace in Gujarat and have assumed alarming proportions. Kotars mainly exist on the banks of the Mahi, Watrak, Meswa and Sabarmati rivers. In the catchment areas of these rivers lie vast stretches of soft but alluvial fertile soil. In other parts of the State though the problem of kotars is there, the intensity is not very severe as the kotars have reached their base level of erosion down to hard stratum and their extension or retrogression longitudinally and sidewise is minimized considerably. In the case of kotars in Gujarat, the nature of the soil being alluvial, the extent and intensity of damage are severe and equally alarming. Due to uncontrolled condition of the water coming from the ridge side of a kotar as well as the fluctuations in water levels of the main river, i.e. by the eroding action of the rain and river water, the soft soil gets eroded and eroded, thus throwing large areas out of cultivation. Periodic flow of water removes from the floor the material washed or fallen into the gully and gradually deepens the channel. Caving and slumping of the gully walls increases the width and the flow of water from the catchment of the kotars helps to develop side channels which eat into the adjoining fertile land. Another method of formation of a gully or kotar is by what is called 'waterfall erosion'. Water falling over the edge of a gully or the bank of a ditch forms deep and very rapidly extending gullies. A small vertical fall usually developes in the

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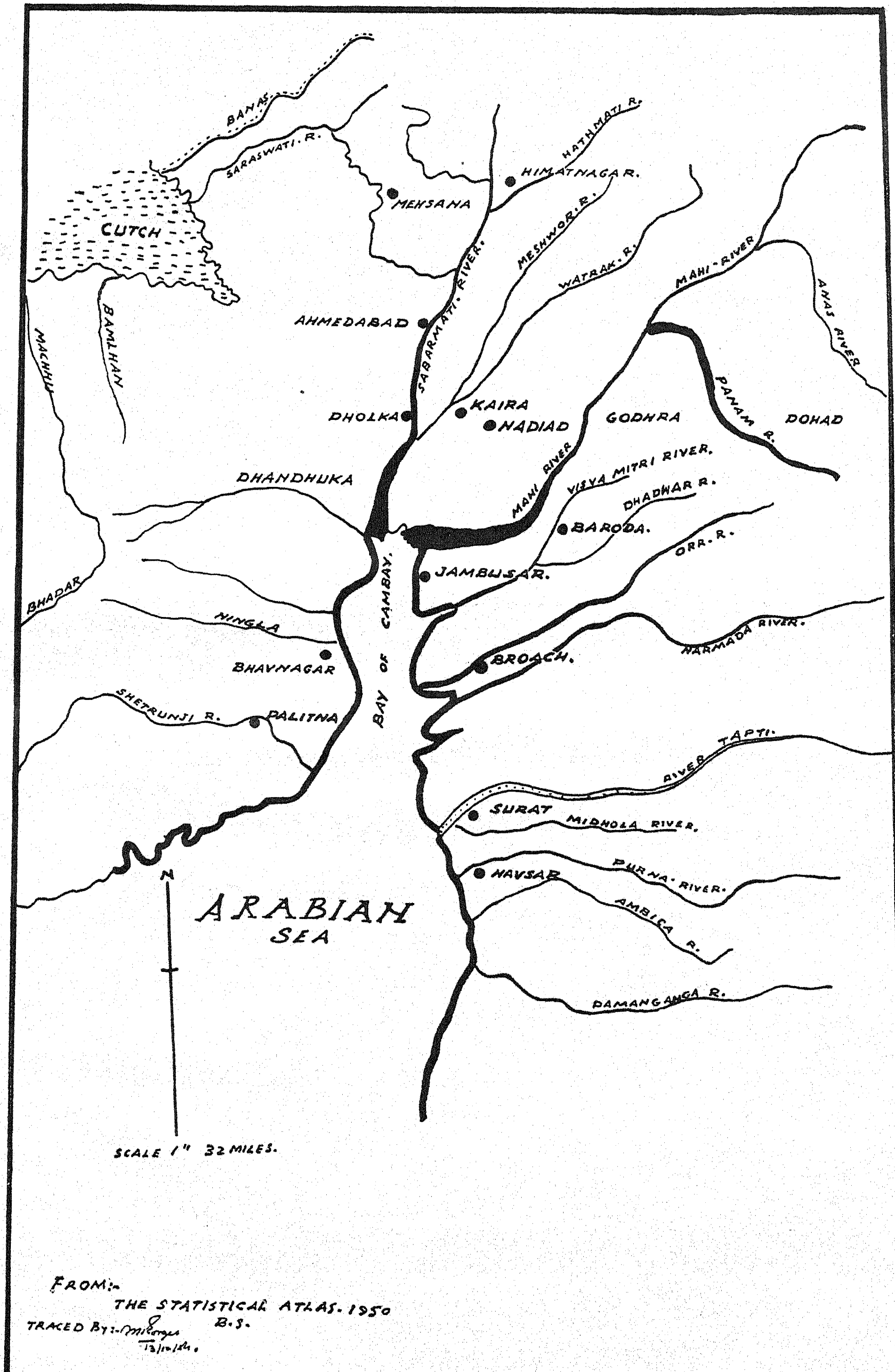

FIG. 1 — A MAP SHOWING THE RIVERS AND RIVER BASINS IN GUJARAT

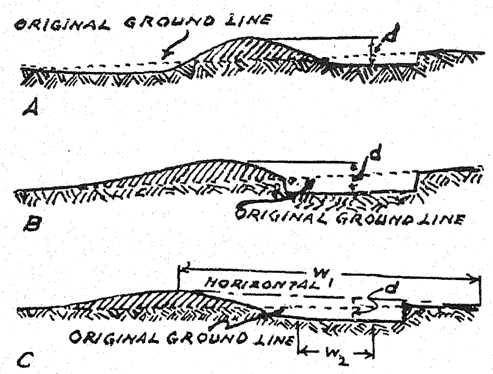

FIG. 2 — DESIGN OF DIFFERENT TYPES OF DIVERSION DITCHES

Diversion-ditch cross sections: *A*, Terrace Type Diversion Ditch on relatively flat slopes. Construction from both sides. Minimum value of *d* about 18 in. *B*, Terrace Type Diversion Ditch on steeper slopes. Construction generally from the upper side only. Minimum value of *d* about 18 in. *C*, this type of diversion ditch is suggested for drainage areas exceeding 10 acres, especially on the steeper slopes. *d* should be a minimum of 22 in. Side slopes should be at least 4:1 where land slopes permit. The approximate water cross-sectional area of the ditch is $\frac{w_1+w_2}{2}d$.

lower reaches of a drainage way, and water falling over it undermines the edge of the bank, which caves in and the waterfall moves upstream or retrogrades. As the waterfall moves up the slope, its vertical height increases, since it leaves a relatively flat slope below. This undermining goes on rapidly, particularly if the surface soil is sand or such easily erodible subsoil. Thus the kotars aggressively encroach on the adjoining land at a fast rate may be 2 to 15 ft. per year and thus it is estimated that there are some 2 to 3 lakh acres of fertile land inviting reclamation.

So far no research work has been carried out in this country as to the methods of reclamation of such lands. In the U.S.A. such lands are reclaimed by constructing a large number of masonry works like masonry plugs, drop inlets, flumes and culverts with high sills to reclaim the eroded land. In the State of Bombay the present orders of Government are that the reclamation of such lands should be executed through the agency of priviate individuals and their enterprise. Lands are disposed of in 50-acre plots to individuals by the Collectors of districts.

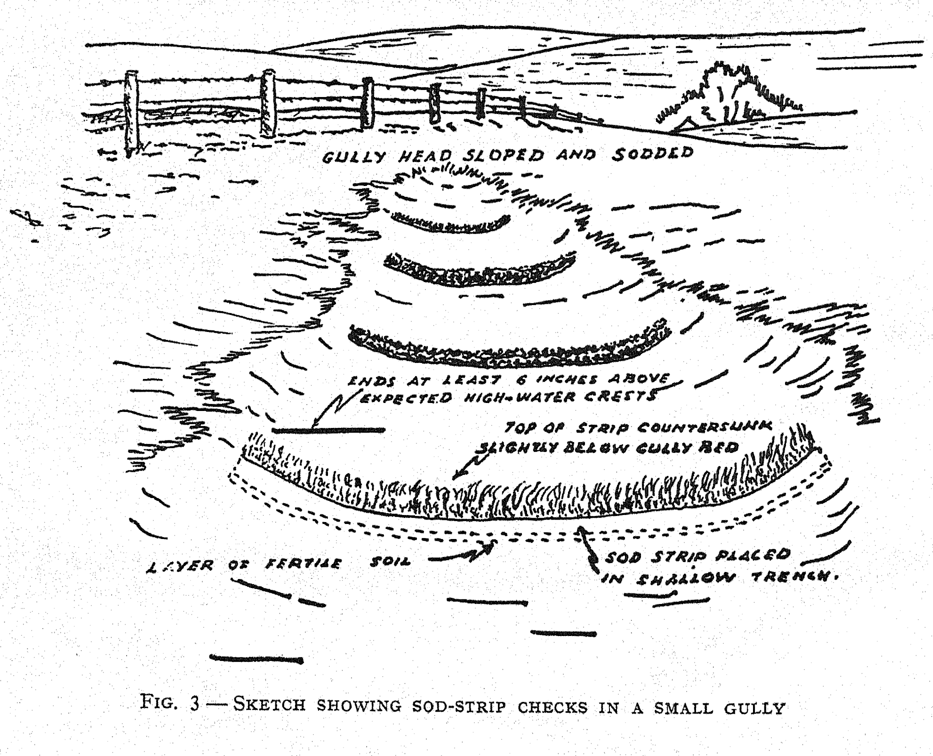

FIG. 3 — SKETCH SHOWING SOD-STRIP CHECKS IN A SMALL GULLY

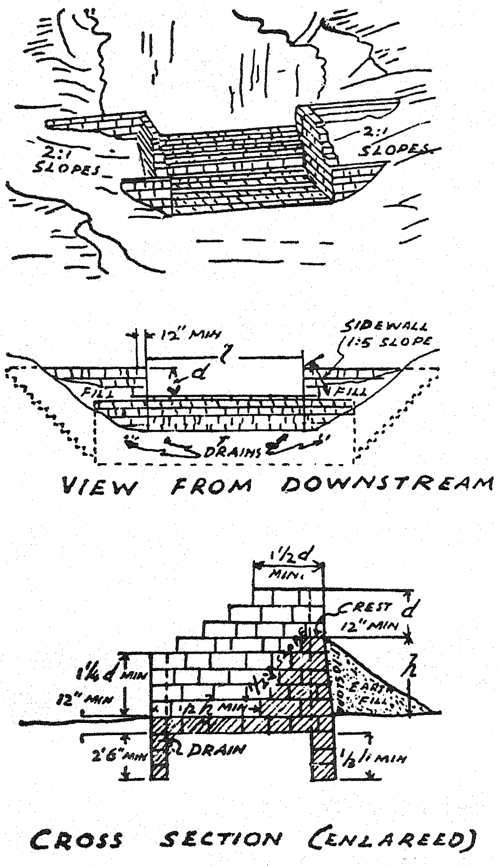

FIG. 4 — SKETCH OF A RUBBLE MASONRY CHECK-DAM

The reclamation works have to be carried out by the grantee according to a plan to be approved by the Director of Agriculture and the Superintending Engineer concerned. The land will be on lease for the first ten years, by which time it should be fully reclaimed and if fully reclaimed within ten years, it is granted permanently to the grantee on the new and impartible tenure without charging any occupancy price. One-fourth of the assessment is recovered for the period from 11th to 15th year of the grant and only three-fourths for the period from 16th to 20th year, full assessment being charged with effect from the 21st year.

It is observed that only a few adventurous farmers come forth to make use of the above concessions. The reclamation works have cost them anything from Rs. 500 to Rs. 1,000 per acre. After 4-5 years of intensive agriculture including heavy fertilization, the lands have started yielding good results. It is now the idea of the Union Government to start a research centre to find out methods of reclamation of such kotar lands.

The following methods are suggested to start with. These methods are suggested both by observation of such works carried out by enterprising farmers and study of methods adopted in other countries notably the U.S.A. The size of the kotars and its drainage area are of great importance in planning the control measure. Each case has to be studied and decided on merits, e.g.:

(a) If a kotar has almost already advanced within a short distance of the divide line, it may not be necessary to spend much on its control, because it is not going to extend further. Our attempt must be to prevent further spread and, therefore, further damage by the extension of the kotar and later to reclaim the kotar land itself if suitable for cultivation.

(b) If a kotar has already reached hard material or in geological terms ' its base level of erosion ', further damage to the kotar itself is unlikely, but its further extension to adjoining cultivable land has to be prevented by suitable measures. Simple devices like closure of the kotar area may suffice to heal the kotar sides and bed.

(c) If the gullied land by kotars is cultivable and valuable to grow crops, it may be justifiable to fill the gully by suitable measures like construction of silt-retention dams and other structures either of a temporary or permanent nature.

It must be clearly remembered that complete gully control includes proper treatment of the drainage area as well as of the gully itself. Stomachache has to be cured at the mouth and not by application of some ointments on the stomach itself.

(d) In a case where the flood water of a river has been responsible for the formation of kotars as is mostly the case specially in Gujarat areas, it may be necessary to grade the bed of the kotar itself up to, or slightly beyond, the high flood influence of the main river by having suitable grade of say 1 in 10 and allow grass to grow over this ramp. The area above this point may be reclaimed if the land is costly and fit for crops by extensive ' cuts ' and ' fills ' of the kotar bed. Perhaps a bulldozer may be more suitable and cheaper in such alluvial areas. The

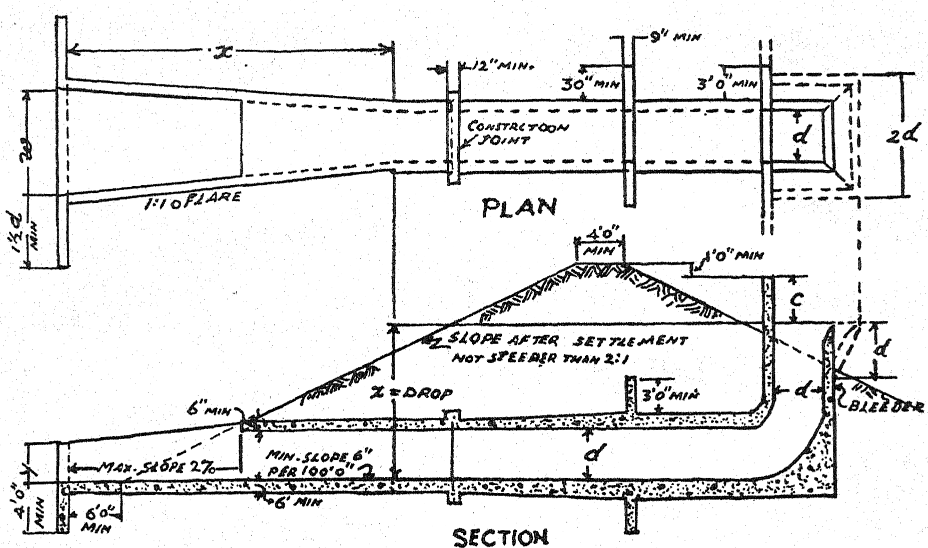

FIG. 5 — SKETCH OF A DROP-INLET SOIL-SAVING DAM WITH SQUARE CULVERT

The drop-inlet soil-saving dam with square culvert. The following specifications are recommended: Square culverts should be 2 by 2 ft. or larger. If smaller sizes are required, round culverts are used. The outlet width, w, should equal the culvert width d plus 6 ft., except for a culvert 2 ft. square, in which case, w equals 6 ft. The length x of the flared outlet equals the shorter of 10 d or 30 ft.; C equals the highest expected flood crest in feet over the inlet lip plus one-half foot.

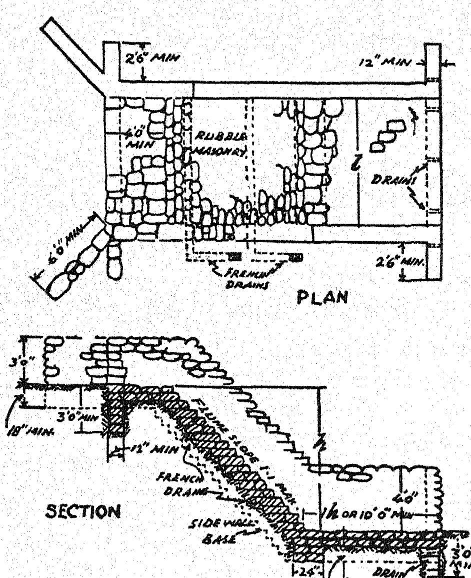

FIG. 6 — SKETCH OF A MASONRY HEAD FLUME

sides of the kotar themselves have to be eased and cured. Just at the point of the high flood level of the main river and the upper reclaimed area a retaining wall may become necessary to prevent scour and wash-off of the upper reclaimed area.

In some case if the main kotar itself is narrow but its branches are extensive and wide, it may become necessary to leave the main kotar as it is, but adopt suitable measures on the side-kotars. If rainfall and climatic conditions are suitable, small grass bunds may heal a small gully. Thus it is clear that an extensive land utilization and engineering survey will become necessary before reclamation measures are decided upon in any case.

(e) In all cases the banks of the kotars have to be protected from bank erosion by suitable methods, i.e. canalizing the kotar, easing of side slopes and plantation of trees and shrubs and by suitable closure of eroded lands to grazing.

It is felt that the above methods may be tried, as so far there is no information in this country about cheaper methods. It will be realized that we have to evolve a cheap method as some 2 to 3 lakh acres of such fertile land now fallen into disuse have to be reclaimed. Thus any cheaper method evolved can be used over a large area and thus save the ultimate cost of reclamation.

Culture of *Pennisetum Pedicillatum* in Bihar for Forage and Soil Conservation

by S. K. MUKERJI &
B. N. CHATTERJI

Introduction

A CRITICAL examination of our natural grass flora for pasture in Bihar reveals that as a result of overstocking of pastures close grazing has led to the replacement of palatable tall growing perennial grasses by dwarf species, viz. *Panicum flavidium, Panicum prostratum, Chrysopogon aciculatus, Digitaria sanguinalis, Setaria glauca*, etc. Most of these grasses produce little green herbage for a short period of the year, hence are not suitable as forage grasses. Most of the tall grasses that persist in the field for a considerable time of the year generally are unpalatable to livestock except in the young stages and usually have pernicious rootstock, such as in *Saccharum spontaneum, Sorghum halepense, Andropogon muricata.* Thus any grass which grows for about 8 or 9 months in the year under conditions of heavy rainfall during the monsoon season and dry season in the post-monsoon period and yields sufficient nutritious and palatable herbage would be the ideal forage grass for our people. After growing it for the last three years at Sabour it appears that *Pennisetum pedicillatum* approaches closely the ideal characteristics stated above. It starts growing vigorously with the onset of rains and continues to grow till March. However, the growth during winter is rather poor. The advantages of this grass over the Napier grass (*Pennisetum purpureum*) are that it can be propagated very easily by seeds. It is very highly palatable to livestock but is not so difficult to remove from a field. Even under adverse seed bed conditions it can be established.

Origin and Distribution

Haines[3] mentions its occurrence in Chotanagpur, hence it can be regarded as a native grass of Bihar. The authors have seen it growing in the hills round Gaya. The strain under observation was obtained from Nigeria in Tropical Africa through the courtesy of Agricultural Chemistry Section, Sabour. In Nigeria it is regarded as one of the most versatile pasture grass. Blatter and McCann[1] have mentioned its occurrence in Bihar, Rajputana and the Western Peninsula.

Description of the Plant and Seed

The seeds of *P. pedicillatum* are very small, enclosed inside glumes which are further hidden in luxuriant growth of hairs. It is an annual grass with stems growing up to a height of 3 to 4 ft. The stems branch from the base and carry broad leaves. The plants tiller profusely, thus ensuring quick recovery after a cut. It has no vigorous rootstock, hence is very easy to remove from an arable land needed for growing any other crop in a short rotation. Under Sabour conditions the grass flowered profusely a month later than that of Rhodes grass, Blue panic and *Paspalum dilatatum.* This grass produces profuse quantity of seeds for propagation. The wind disperses the light fluffy seeds for natural spread.

In the first year of its growth at Sabour it was observed that there was great variation among the individual plants, particularly in the inflorescence colour and structure. These were labelled and bagged for further study. Next year they were sown separately in small plots. Five distinct strains have been isolated by the authors which are breeding true and are showing considerable variation in green fodder production. Isolation and multiplication of more productive types are under progress.

Sowing

It can be grown both as a fodder crop on arable land or as a forage on *bunds* or road

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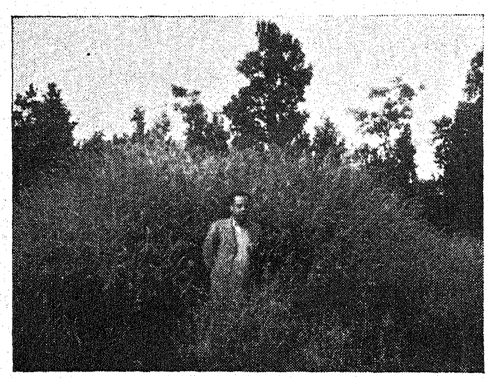

PROF. S. C. MANDAL IN A CLUMP OF *Pennicetum pedicillatum* ON ERODED SOIL OF NETARHAT FARM ON 5 P.C. SLOPE

sides. This grass does not need very fertile land for its establishment. The seed bed need not be made very fine. It may be sown with irrigation in the month of April otherwise with the break of the monsoon. It may be seeded behind a country plough in the furrows 2 to $2\frac{1}{2}$ ft. apart at 1 to 2 in. depth at the rate of 2 to 3 lb. per acre. The seeds take about 3 weeks to germinate. Once it is sown in one field, it is seen that in the next year seeds that had been shed over the soil start germinating and growing from the very onset of the few light showers in April or May. This helps in spreading the grass in the interspaces and smothering the weeds. For establishing it on minor irrigation *bunds* or roadsides the best time to sow is when new earth has been put on the embankments. The newly piled soil may be grubbed by a hand hoe or a garden rake after the first monsoon shower and then the seeds may be broadcast and lightly mixed with the top soil.

During the current season (1954) five grasses *P. pedicillatum*, Rhodes grass, Blue panic, thin napier grass and *Andropogon guayana* (a newly introduced grass) were sown in chain lengths, replicated over the newly repaired northern *bund* at the Sabour farm in June. It was observed that in every replication *P. pedicillatum* established best providing complete coverage to the soil with vegetation and smothering of the weeds as compared to the other four grasses. Thus this grass proved to be the most efficient agent in saving the new soil put on the *bund* in spite of occasional grazing by cattle. Similar reports have been received from some P.W.D. executive engineers who tried this grass on roadside embankments. Shri S. K. Ghosh, Superintending Engineer, South Bihar Waterways, has reported successful establishment of this grass supplied by the authors on the canal banks in Sahabad district.

Management

Where the grass has been sown in lines, it is possible to interculture and drill in some associate legume. At Sabour in the second year of the crop *Phaseolus mungo* was sown in between grass lines after the onset of monsoon. The grass was kept in check by cutting at the initial stages of the growth of the legume. Later legume was found to compete with grass in growth. Similarly, after the harvest of this *kharif* legume and subsequent interculture between the rows, *Melilotus alba* (Hubam clover) was sown in the beginning of October. As the grass does not grow so vigorously with the dropping of temperature, it was not necessary to keep it in check to allow the legume associate to grow. This practice of growing grass with legume will increase the nutritive value of the forages and perhaps upgrade the fertility of the soil. Moreover, the growth of weeds is considerably reduced by growing the mixture. Some undesirable weeds, like *Amaranthus spinosus*, may be removed whenever possible. For quick recovery after a cut, care should be exercised that the crown of the plant is not damaged in any way. The safest procedure is to take cuttings at a height of 4 to 6 in. from the base. This grass does not thrive under waterlogged conditions, where grasses like *Digitaria sanguinalis* and *Panicum colonum* suppress its growth.

Normally three cuttings can be taken at intervals, like end of July, middle of September and end of October. After the last cut the grass may be left alone to form seeds and to regenerate with the rains. Under conditions of average fertility at Sabour the yield varied from 500 to 600 mds. per acre when grown alone and went as high as 800 mds. per acre in association with legumes. This grass responds well to fertilizer application. A top dressing after the first cut at the rate of 20 seers of ammonium sulphate per acre will add another additional 100 mds. of green herbage. Poor and stunted

growth should be remedied with nitrogenous manuring. At Pusa on fertile soil the yields as high as 1792 mds. per acre were estimated in small experimental plots in 1955 indicating the high yield potentiality of this grass as a fodder crop.

Feeding Value

This grass is extremely palatable to livestock. It compares favourably in nutrition with the well-known fodders as Napier grass or green Jowar. The leaves contain most of the nutritive constituents. The grass should always be harvested when 2 to $2\frac{1}{2}$ ft. high so as not to lower its nutritive value as it becomes mature.

During the last *kharif* season this grass has been sent to all the farms of the Department of Agriculture, Bihar, to study its adaptation under different environments. Reports of its successful establishment on eroded poor acid soils have been received in 1955 from Netarhat and Chianki farms.

Summary

A new fodder grass *Pennisetum pedicillatum* suitable for Bihar has been described indicating its advantages over the fodders being grown so far. The method of culture both on arable land and also the embankments has been indicated. Introduction of legume associate with the established grass to improve forage quality has also been shown.

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The Role of Forests in Flood Control

by V. S. RAO

IN dealing with the subject at the present stage of our knowledge it should not be necessary to reiterate fundamental principles which have not only been quantitatively established by well-planned scientific experiments, but, being matters of common observation, have come to be universally accepted by laymen as well. For example, there should be no need to labour the arguments (i) that a portion of the rain falling on a forest gets caught up on the surfaces of leaves, twigs, stems and branches, and trickles down to the ground, (ii) that the force of rain drops is retarded at several stages by the various tiers of the green canopy, (iii) that the leaf litter and humus which exist on the floor of a properly maintained forest absorb sponge-fashion some of the precipitation, (iv) that the roots of trees, shrubs and grasses which penetrate the ground greatly assist in the percolation of water into the soil, (v) that increase in the velocity of runoff water enormously enhances its power to carry soil, pebbles and boulders, and (vi) that the outflow from a forested region is, therefore, far less rapid, less voluminous and less turbid than that from a bare area.

These statements and observations appear so obvious to any ordinary intelligence as not to admit of any debate; and once these cardinal points are recognized and granted, there could and should be no doubt in the minds of people regarding the part that forests play in the control of floods in regions liable to periodic inundation. It must, therefore, be a matter of some surprise when people profess to be sceptical about forests being important agents in the prevention of flood disasters. Disbelief and misconception can be due to various causes some of which will be examined during the course of this paper.

In regions where rainfall is generally small and ordinarily not torrential, as in parts of the Eastern Ghats, the denudation of the

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hills may not result in catastrophic floods. Erratic and unexpected swelling of streams, and minor floods do occur but pass muster. There are other evils attendant on deforestation, viz. lowering of the water tables, lack of sufficient humidity in the atmosphere (which has an adverse effect on agriculture), silting up of waterways, etc. but in a country where a cataclysm is required to rouse a philosophical people to activity, such minor evils are given little consideration, although their cumulative effect may be very grave in the long run.

Again, it can happen that, although there is a forest in the catchment, its anti-flood-control status may have greatly deteriorated due to (a) poor stocking, (b) coppicing at frequent intervals, (c) grazing and annual firing, which eliminate the humus and leaf litter, spoil the grass cover, compact the soil, reduce infiltration and increase the runoff. Such forests may further lack continuity, leaving large, if irregular, blocks of exposed land where poor systems of agriculture or too intensive grazing create conditions suitable for erosion. These circumstances prevail in the catchment of the Damodar Valley. And people who do not closely observe the actual state of the forests and the malpractices that contribute towards flood incidence may be led to doubt the efficacy of mere forest cover against the forces of nature. In similar areas, the improvement of the soil cover by effectively keeping out fire and cattle, and by connecting up the patches of forests by reafforestation can alone demonstrate the beneficent role which forests no doubt played in the past centuries of good behaviour of the river.

From considerations of conditions in such regions, when we turn our attention to the Himalayas, we are apt to fail to realize the magnitude of the titanic forces involved. The Himalayan region is the largest mountain system in the world, occurring at a relatively weak zone of the earth's crust as a result of pressure between two hard land masses. The forces had been so great as to crumple the sedimentary strata laid under the sea of Tethys into the highest mountain system in the world. The strata have been folded and upthrust, crumpled and metamorphosed by gigantic pressures, so that some of them stand at very steep angles. Amongst this vast tumbled mass, atmospheric precipitation had been busy during geological epochs cutting and carving, eroding and sculpturing, until the eventual establishment of conditions stable enough to favour the growth of vegetation permitted progress towards a balanced high-forest cover. Meanwhile the courses of the streams had been well formed, and an orderly state of things prevailed, with nature at peace with herself — a sort of *Pax Sylvatica*, if one might say so.

What is more important to bear in mind, particularly with regard to the Eastern Himalayan region, is that this balance had been built up in respect of what is one of the biggest rain-making agencies in the world, viz. the monsoon current arising from the Bay of Bengal. This current, which blows for nearly six months in the year, carries an enormous quantity of moisture, hits the earth's biggest mountain range, and, unable to cross it, causes extensive conditions of rainfall from Assam to the Punjab, both in the hills and in the vast stretch of plains below. In the hill portion of North Bengal, Sikkim and Bhutan, as well as in the sub-montane regions immediately abutting it, the rainfall is not only heavy considered as an annual precipitation (100 to over 250 in.), but storms of great intensity (20 in. in 24 hours) as well as incessant downpours over several days are not uncommon.

Another notable feature of this region is the instability of its underlying rock which is composed of sandstones, quartzites, shales, slates, phyllites, schists and gneiss, loosened and crushed by folding and crumpling. In the lower regions occur compacted alluvial detritus composed of soft sandstones, mudstones, shales and conglomerates.

That the magnificent sylvan clothing of these hills and the Terai and the Dooars had been established during several millennia in the face of so many adverse natural factors is proof of no mean order of the stabilizing effect of vegetation, especially of a many-tiered " high forest ". When early civilized man came on the scene with axe and fire, with domestic animals and agricultural crops, little did he reckon the magnitude of the odds he was up against. Little did he know that raging elemental forces had been securely shut inside a sylvan box, and human Pandoras should be wary in prying open the lid.

Nor can it be said that we are generally much wiser (though certainly sadder) today. The destruction of the protective forest cover has thoughtlessly gone on for centuries —

very much faster during the last five decades — the local balance of nature has been badly upset and we now live in an anxious era of landslips and floods. It is a significant fact that really serious disasters have been happening after the last world war during which over-exploitation of the forest (outside the area managed by the Forest Directorate) and expansion of human activity have occurred in the region — the bad years were 1950, 1952 and 1954. The road and railway system in North Bengal had never before been so badly wrecked, nor had the towns in the plains been threatened with such a serious problem of inundation.

The distressing part of it is that these disturbing features appear to have come to stay. And even in face of these, there is neither a tendency to stop further denudation of the hills nor a significant effort to extend the protective cover of forests over sore spots. Although it is recognized that there is general ill health in the physical conditions of this region, the tendency is merely to apply local remedies and do surgical operations (which, in the circumstances, are doubtless indispensable) and to ignore the restoration of the general health of the body by proper dieting and recuperative treatment (namely by afforestation), which, though a longer process, is more efficacious in curing the disease.

It, therefore, behoves us once more to get down to fundamentals and see how it is that forests have so long maintained the stability of this tract and how they may once more be able to do so.

The destructive action of water is of three kinds: (a) excessive volume, leading to overflow and submergence of areas, mainly in the plains, (b) excessive rapidity of flow which causes the loss of the fertile top soil and eventually to erosion of a more serious nature, leading to the formation of ramified gullies and chasms, (c) transportation of soil, pebbles and boulders and dumping them at various places along the river course, thus gradually raising the bed of the river. It will at once be obvious that the third circumstance leads back again to the first, i.e. the raising of the river bed leads to the incapacity of the river to contain spates resulting from even moderately heavy rains.

Anyone who has watched the streams in the sub-montane zone of North Bengal in relation to the excellent road and rail communications in the Terai and the Dooars during the last quarter of a century could not have failed to notice with alarm the gradual raising of the beds of the various mountain streams — Mechi, Rakti, Rohini, Balasan, Mahanadi, Tista, Lish, Ghish, Chel, Mal, Neora Nuddy, Murti, Jaldhaka, Daina, Rehti, Toorsa, Kaljani, Rydak and Sankosh. Spectacular instances are those of the Lish and the Ghish and in a certain respect of the Tista as well. The time appears to have come when we should expect flood disasters as an unfailing annual feature. The following statements are beyond contradiction, that the raising of the river beds is due to transportation of detritus by the streams, that the large quantity of detritus originated from eroded hill-sides, and that erosion on hill-sides is directly due to deterioration of the catchment areas mainly as a result of deforestation. But there are persons who, while agreeing with this view, tend to brush aside the need for large-scale afforestation on the following grounds: (a) the damage is already done and immediate solution is necessary, (b) afforestation is a long-term process and cannot offer present protection, (c) forests, in any case, have no reducing effect on peak discharges, once the soil is soaked in the first month or so of the monsoon.

It is in respect of the last statement that a closer examination is very necessary.

The role of soil in mountain hydrology will be clearly apparent when we consider soil as that portion of weathered rock which is capable of absorbing and giving up moisture and which acts as a medium for the roots of vegetation. It does not require much imagination to visualize that if the Himalayas were to be re-cast in a material like glass, with a smooth and unsoaking surface, every ordinary precipitation would lead to flooding in the plains; there would be no seepage water and no perennial springs or streams. It is the moisture-retentive power of soil that makes all the difference in the conditions of a catchment. The pore-space between the particles of soil which is ordinarily about 50 per cent by volume permits the water to percolate, and keeps it in temporary " detention ", releasing it slowly into the streams by seepage.

It, therefore, follows that the greater the extent and depth of soil in a watershed, the

greater the temporary storage capacity. The chief agent in soil formation is vegetation, mainly with the aid of roots. Roots not only exert a physical pressure but also act chemically in the disintegration of rock surface. The roots of forest trees go deeper than those of agricultural crops or grass, and, therefore, the deeper is the weathering of the underlying rock and consequently the greater is the depth of soil under a forest. Forested areas, therefore, help to absorb and keep water in detention much more than exposed land or agricultural land; in the latter areas the process of weathering of the underlying rock is naturally very slow.

The storage capacity of a soil is also affected by the nature of the surface. If the surface is impermeable, the storage capability of the soil is greatly vitiated as water is unable to get down to the underlying storage space. An impermeable surface is created by compaction resulting from treading by men or (more effectively) by cattle or by the beating of rain drops on an exposed and improperly protected soil surface. The leaf litter and humus that cover a forest floor not only themselves absorb rain water but also improve the permeability of the soil. The roots of forest trees pierce convenient passages for water to get readily into the deeper layers of the soil. Dead roots form ready-made channels and storage space.

Moreover, organic matter is abundant in forest soils and is found at much greater depths there due to decomposition of roots and the presence of bacteria and other organisms. Organic matter acts like a gel and expands considerably with soaking. In the colloidal state it can absorb as much as 4·4 times its weight of water. There being little scope for lateral expansion of soils the movement is upward, the result being an increased depth with consequent enhancement of storage capacity. The detention of water so achieved over vast areas of wooded catchments is of considerable magnitude and is an effective factor in the regulation of stream flow and the control of floods.

The water storage so far referred to is that relating to the non-capillary pore space in the soil. Water is held by soils in quite another manner as well, viz. by capillary action and by "adsorption" by the surfaces of soil particles. The force with which a molecule of water is held by a soil particle decreases rapidly with increase in distance from the surface of the particle. The first fine liquid film next to the surface of any solid is held more tightly than the outer films.

Water retention effected in this manner by soils is almost unaffected by gravity. It is now easy to understand that the larger the surface presented by the particles constituting a soil, the greater its "retention" storage capacity. The finer the particles, the greater the surface presented and, therefore, the greater the "adsorptive" effect; the total superficial extent of all the particles into which a boulder is pulverized is enormously greater than the surface of the unbroken boulder. It is estimated that clay can hold 9 times as much water against the force of gravity as fine sand. The roots of plants and the bacterial activity inside a forest soil keep it in a finer state of division and to a greater depth and hence increase its retentive capacity.

Moreover, an irregularly shaped particle presents a larger surface than a round particle of the same volume. Organic matter in the soil tends to attach itself to soil particles and to give them irregular shapes, thus vastly increasing their superficial dimension and consequently adding greatly to their adsorptive power.

One more point is to be considered in this connection. The storage capacity of a soil is increased by the removal of water. Evaporation is only one of the two agencies by which soil-water is returned to the atmosphere, and the depth to which it is effective is very small. In forested regions loss by evaporation is practically eliminated. But the removal of water by "transpiration" is quite a potent factor in increasing the water-storage value of a wooded area. The transpiration effect is greatest at field capacity and decreases with the depletion of soil water. The force required to separate water from soil at field capacity is approximately 5 lb. per square inch, whereas at wilting point it is 225 lb. per square inch. When, therefore, the soil is soaked, the pumping action of the transpiration current is greatest, and *is constantly creating additional storage capacity.*

It is important to note that roots transpire water with the same vigour simultaneously throughout their length. It means that water is being pumped out of various soil depths at the same time. The longer the root-system, therefore, the greater the storage capacity induced by transpiration. As roots

of forest species penetrate to great depths, the water-retentive capacity of a forest soil is extremely high.

These conditions do not obtain either in pastures or in scrub or in agricultural land, certainly not in bare and exposed soils. In addition to this one has to consider the capacity of interlaced root systems to hold soil in position on slopes. The ramification of rootlets grips the soil like a veritable reinforcement and helps it "to stay put". The removal of vegetative cover compacts the soil, reduces infiltration and, therefore, enhances runoff. This leads to erosion and loss of soil depth, and consequently of water storage capacity.

There is far better weathering of rocks under forest soils, which are, therefore, deeper. The infiltration is greater due to the porous texture of the soil resulting from continual addition of organic matter and bacterial activity which again tend to increase the depth of soil. Transpiration is a great agent, at field capacity, for increasing water storage possibility. Besides, there are the surfaces offered by leaves, twigs and branches of the various tiers of vegetation, the moistening of which accounts for part of the precipitation; and the absorbent humus and leaf litter account for another significant portion of the rainfall. The retardation of the force of rain drops at the various canopy levels gives a vastly greater opportunity for the water to soak into the soil which is kept nicely permeable by the organic content of the soil as well as by the deep root system and bacterial action. Bearing these points in mind there can be little doubt regarding the magnitude of the role that forests play in the matter of flood control.

In the ultimate analysis, however, the problem is one of sociology and economics. Two events are happening, which exercise a profound influence on the attitude of men towards the issue — one, the population of these hills is steadily growing beyond the capacity of this region to maintain them even at the present low levels of the standard of living; two, the extent of fertile land itself is diminishing year after year by erosion and the loss of the protective influence of forest cover. The critical point is not far off, if it has not already been reached. With the administrative officer the clamour of a growing land-hungry population is likely to overwhelm the consideration of the imperious need for retention and extension of forest cover. The stresses created have the psychological effect of belittling, in the minds of even intelligent folk, the immense value of forests in these derelict water-sheds.

It is an unfortunate circumstance that the rivers in these mountain ranges tend to carve out gorges rather than form broad valleys with easy slopes which would have permitted the planning of agricultural development and flourishing towns at the bases of the hills leaving the hill-tops and middle slopes covered with well-managed forests and pasture. The alternative is to strictly delimit agriculture to the easiest slopes, leave the gorges well covered with forest, bring marginal agricultural lands under a forest cover, ensure a regular supply of coke to all the sizeable towns in the hills, provide cheap electricity if that is possible in connection with dams that might be necessary to control the floods, and discourage the *unregulated* felling of trees for firewood or timber or for extension of agriculture in dubious localities.

Most of all is it necessary to carry home to the man in the furthest locality that to start a sore spot in the hills by his maltreatment of the land is not only a national crime but is fraught with danger to himself and his progeny. Limitation of population is one of the most important desiderata for the success of this mission, but until that becomes practicable, the need of taking up on a large scale the education of both the governors and the governed in the wise exploitation of land resources cannot be over-emphasized.

The problem of restoring catchments to health is complicated by the limits imposed on such restorative work by international frontiers. In the case of North Bengal, the upper catchment of one of its largest rivers, the Tista, lies in the Sikkim State; it may, however, be noted with gratitude that all co-operation in the matter of investigation is being obtained from that State. But from the Jaldhaka eastwards the entire catchments of the rivers lie within the hills of Bhutan whose territory is a closed book to us. The remedy here lies wholly beyond our frontier. At present we only look from afar with dismay at the deforestation going on in those hills which are visible to us. We guess that similar denudation has taken place or is in progress in other parts of that territory, judging by the state of the rivers which have behaved most erratically within the last

quinquennium. Until better conditions can be ensured in the mountain region forming the catchment of these rivers, the plains of eastern Jalpaiguri and Cooch Behar will continue to suffer. It is little consolation to know that the ruination of water-sheds not only afflicts the dwellers in the distant plains, but is bound sooner or later to undermine the very basis of existence of the folk up in the hills. It is to be hoped that before conditions deteriorate too badly, there will be an awakening amongst the countries concerned to the dangers of catchment misuse, and that determined attempts will be made towards organized living in order that the final disaster may be averted.

CORRIGENDA

Vol. 3, No. 1, October 1954

LIST OF NEW MEMBERS OF THE SOIL CONSERVATION SOCIETY OF INDIA

1. Page 39, col. 1, line 9 from top
   for HASTEREADM, *read* HEADMASTER

Vol. 3, No. 2, January 1955

APPENDIX II, NEW COUNCIL

1. Page 74, col. 1, line 11 from bottom
   for DR. J. S. PATEL, *read* DR. J. S. PATEL, M.S. (Agri.) Cornell, Ph.D. (Edin.), F.A.Sc.
2. Page 74, col. 1, lines 8 & 9 from bottom
   for SHRI J. N. PANDEY, M.S. (Agri.) Cornell, Ph.D. (Edin.), F.A.Sc.
   read SHRI J. N. PANDEY, Divisional Forest Officer

Vol. 3, No. 3, April 1955

CROP RESPONSE TO ADDED FERTILIZERS IN CULTIVATORS' FIELDS—A TECHNIQUE FOR FINDING OUT MANURIAL REQUIREMENTS OF BIHAR SOILS

1. Page 98, Table 1, col. 2, heading, *for* 1949-52, *read* 1949-50
2. Page 101, Table 4, Loam, col. 2
   for 0·615, *read* –0·615
   for 0·230, *read* –0·230
   for 0·533, *read* –0·533
3. Page 104, col. 1, line 5 from bottom
   for $Y = A\ (1-e-ex)$, *read* $Y = A\ (1\text{-}10^{-cx})$
4. Page 105, col. 1, line 11 from top
   for $Y = a_0 \times a_1x \times a_2x^2 \times a_3x^3$, *read* $Y = a_0 + a_1x + a_2x^2 + a_3x^3$

LIST OF NEW MEMBERS OF THE SOIL CONSERVATION SOCIETY OF INDIA

1. Page 132, col. 2, line 11 from bottom
   for *PRASAD, B., A.A.S., *read* *PRASAD, B., I.A.S.

Flood Control Problems*

by LUNA B. LEOPOLD &
THOMAS MADDOCK JR.

General Considerations

THROUGHOUT the world, alluvial soils are among the most fertile and easiest cultivated. Alluvial valleys are routes for transportation either by water or by road and railroad. Rivers are sources of water, a necessity of life. But these river valleys and alluvial deposits, which have so many desirable characteristics and which have increased so greatly in population, are periodically occupied by the river in performing its task of removing the excess of precipitation from the land area and carrying away the products of erosion.

How a river behaves and how the river flood plain appears depend on the relationships between water and sediment combined with the existing topography. Thus rivers and their alluvial deposits provide an endless variety of forms which are shaped, to a large extent, by the river flow during periods of rapid removal of debris and of excessive rainfall. The mechanics of river formation are such, however, that the highest discharges are not contained within a limited channel. How much water a channel will carry depends upon the frequency of occurrence of a flow. Low flows, which occur very frequently, are not important in channel formation. Neither are the infrequent discharges of very great magnitude which, although powerful, do not occur often enough to shape the channel. Channel characteristics, therefore, are dependent on those discharges of moderate size which combine power with frequency of occurrence to modify the channel from. In the highest discharges of a stream, water rises above the confines of its banks and flows over the flood plain.

It must be considered, therefore, that floods are natural phenomena which are characteristic of all rivers. They perform a vital function in the maintenance of river forms and out of bank flow may be expected with a reasonable degree of regularity.

The demands of the river and man's requirements for land are in opposition to each other. Under light population pressures and low stages of development there is little conflict; but as population pressures increase, more and more of the flood plain is occupied, and greater and greater risks of loss from flooding must be accepted. But sooner or later a flood of unusual magnitude takes place. This is the time when those who have gambled and won for many years must lose, and the relationships between loss and gain is balanced.

There comes a time when the losses, even though they may be economically acceptable, become unacceptable politically and socially. In such cases some level of government undertakes to provide a degree of flood protection to reduce the risk of flood plain occupancy. The greater the magnitude of the problem, the higher the governmental level which undertakes remedial measures. In some areas only a national government can be responsible.

Basically, there are only a few ways in which flood protection may be accomplished. The excess water may be confined between levees or embankments or it may be stored in some place for release at non-damaging rates at a later time. But the most essential factor which must be considered in flood control planning is that only very rarely is it physically possible to provide complete protection against floods; and even more rarely is it economically feasible to provide complete flood protection even if it were physically possible to do so. We know of no case where complete flood protection has been provided against the floods which may be expected from a river basin of appreciable size.

The type of flood control programme selected for a given area is, therefore, one which will conform to local conditions and one which will yield the greatest benefits with respect to its cost and at the same time result in the least harm.

For it must be recognized that there are always some undesirable features which

*With acknowledgement to the Chief Administrator, Kosi Project, Patna, Bihar.

result from attempts to regulate rivers. Foremost among these is the fact that floods have their benefits and elimination of floods eliminates benefits. One important benefit is the maintenance of fertility of the overflowed areas. Another is the increased crop yield which may result from the natural inundation of such areas. There are disadvantages to methods of flood control. Confining water between embankments leads to an increase in flood heights by reducing the amount of water held in temporary storage in flood channels. The same process increases flood problems downstream. Confinement of river flow may result in changes in the relationships between width, depth, velocity, slope and sediment load and may result in modification of river sections, in the positions of bends and meanders, and may cause or result in scour or fill. Storage of flood waters requires land which may be valuable. Releases from storage modify the balance between water and sediment and usually cut or widen channels downstream; but deposition of sediment may also take place in some areas.

More importantly the completion of flood protection works results in increased development in the protected area. People farm areas which were flooded frequently in the past. Buildings are constructed and works of all kinds are built on lands which were previously inundated. When, inevitably, a flood takes place which is beyond the protective capacity of the works, much of the damage which takes place is the result of the flood control plan and is far greater than would have occurred had there been no flood protection.

The basis for decisions on the type of flood control scheme, wherein the advantages and disadvantages of various methods of control and their combinations are weighed, is the collection and analysis of basic data, first for the purpose of understanding the forces and processes involved and second for the purpose of interpolation or extrapolation from known conditions to unknown conditions. In the flood control field the adequacy of disciplines varies widely. Unfortunately the least adequate is probably the most important, the one dealing with stream morphology. This is a very broad subject, since it must consider the hydrologic characteristics, including runoff and sediment movement and their variations with time, and those characteristics associated with the hydraulics of the stream having to do with width, depth, velocity and slope.

Thus we find there is general agreement on some of the methods to be used to establish certain criteria for flood control. Methods are well standardized for determining the size of a flood to be used for various purposes in project design. Procedures for routing flood flows are generally uniform. But the methods of analysing the flow of sediment-laden discharges in alluvial channels have not been agreed upon.

The applicability in a specific instance of standardized procedures is limited by the availability of basic data. Lack of basic hydraulic data for ever plagues the planning engineer, because basic data increase in value with the length of record. Thus projects which are being planned today should have records of precipitation, runoff, and sediment load which were collected at least 25 years ago. In dealing with basic data we have to utilize inadequate data to the best advantage in our current planning and at the same time assure ourselves that 10 or 15 years hence understanding of specific problems and problem areas will be much greater than it is now.

Data Collection in India

The writers are appalled at the magnitude of the flood problems in the Ganga Basin. Essentially these problems result from the filling of the basin with the debris from the Himalaya mountains and their foot hills. This process is complicated by (1) very high rainfall which is seasonal, leading to great variation in stream discharge (2) great difference in elevation which combined with large exposures of geologically young rocks in great topographic relief results in high sediment loads, and (3) frequent seismic disturbances of great magnitude.

We know of no way in which data can be collected to analyse the potential of seismic disturbance, but with respect to the knowledge of rainfall and runoff and the characteristics of sediment load, we find that, as usual in undertaking water resources development, a longer and more diverse record would be desirable. It appears, for example, that rainfall records from locations on the Gangetic Plain are adequate to meet all needs which have so far developed. Records

available from hill and mountain areas leave much to be desired, but this is the usual situation. Too few people live in such areas to permit the establishment of an adequate hydrologic network. Constant pressure is required to expand the network to its practical limits and methods must be developed to extrapolate existing records to areas of no data. Our discussions with the staff indicate that these problems are recognized and efforts are being made to solve them. The results of the effort to expand the network in the upper Kosi river drainage has been outstanding.

Stream flow records do not appear to be as adequate as rainfall records. Many records are simply gage heights. These are of value but not as valuable as records of the quantity of water flowing in the river from day to day. There are essentially only three locations where discharges are measured in North Bihar, and these are associated with collection of data for specific projects. The useful data collected at gaging stations is not confined to records of discharge. Information on stream width, depth, velocity and slope is of great value in many types of studies and these data should be sent to central locations to supplement runoff data.

We suggest that consideration be given to the centralization of complete records of gaging station operations. The advantage to be gained from such a procedure are: (1) A central record body is built up which provides ready access to records of streams having dissimilar characteristics. (2) Ready access permits easy study of records for any purpose which may be desired. (3) Procedures for the collection and analysis of data may be reviewed and the worth of the record evaluated. (4) Responsibility for uniformity and adequacy of technical performance can be placed in a single responsible officer.

The collection of sediment data is in its infancy in India as it is in other countries. Indian methods of data collection were designed for the purpose or estimating rates of sediment accumulation in reservoirs. Procedures are very satisfactory for this purpose, but if the uses of sediment data are to be expanded, it will be desirable for a modification to be made in current procedures. As a case in point, the collection of sediment samples at 0·6 depth results in the over-estimation of fine material and the under-estimation of the coarse material. Many sizes of sediment load which are of greatest importance in determining channel characteristics do not even appear in a 0·6 depth sample.

It is suggested that sampling procedures used in the United States be adapted to meet Indian requirements. We suggest, in particular, the use of equipment equivalent to the type of samplers developed by the United States Federal Agencies which will provide samples of water and sediment moving near the stream bed. For this purpose it is suggested that an adequate number of samplers varying in size from depth-integrating hand samplers for shallow streams and reconnaisance investigations to the heaviest depth-integrating samplers for use on larger streams be obtained from the United States. It is not suggested that the large pointintegrating samplers be secured until the sediment sampling programme is well developed.

There is a series of publications, which should be made available with the sediment sampling equipment, reporting the results of inter-agency studies in the sediment field by the United States Government. These deal with an analysis of various types of samplers, the development of the recommended sampler, methods of securing samples in the field, methods of determining size of sediment particles, reports of field tests of sediment samplers and studies of volume-weight relationships of sediment. We suggest that the conclusions found in these studies be given consideration in developing the Indian sediment sampling programme.

The present method of determination of sediment size appears to be satisfactory. We would recommend, however, that sediment be reported on a weight rather than on volume basis. This suggestion is made because of the great variations in sediment weight which are observed under natural conditions particularly in the finer sizes. At reasonably frequent intervals complete mechanical analysis of the suspended sediment should be made, taking care to secure analyses of sediment carried by a range of discharges.

It seems to us that while the Indian engineer faces great problems, he also faces great opportunities. Nowhere on earth is it possible to study the alluviation of streams with such a wide range of discharges, slopes and sizes of suspended load. Hence from the standpoint of developing the science of river engineering there should be a well

rounded and continuing investigational programme which would cover the Himalayan front. We are firmly convinced that the returns from such a study in the form of more precise planning, lower construction costs, freedom from operation problems, and lower maintenances costs will be many times the expenditures necessary to finance such studies. These studies are not research in the abstract sense. They are highly practical and have the definite objective of aiding in the sound development of water resources.

Such a programme would correlate field surveys to determine stream slopes, size of bed material, river cross-section (which should include rivers of such magnitude that supersonic depth-finding equipment must be used in their measurement) with hydraulic studies. The latter should deal with stream width, depth, velocity and roughness, and with measurements of suspended load and its size, together with the flow of the streams, and the frequency of various discharges. Enough work has already been done in India to indicate that such a programme would be effective. What are now required are funds to defray costs, manpower to undertake the work and energy to drive to a successful conclusion.

Principles and Observations Relative to River Morphology

The authors have been personally concerned with research in the mechanics of rivers, the inter-relation of discharge, sediment load, and the shapes and patterns of river channels. Though our experience in India has been insufficient to analyse the operation of these factors in the rivers of India, we believe that an outline of some observations made on American rivers might provide some analogies applicable to Indian conditions.

A river builds its flood plain and carves its channel in response to the discharge and sediment load provided by the drainage basin. The amount and distribution of water and the quantity and size characteristics of the sediment debris are functions of the precipitation, geology, topography and physiography of the drainage basin. These qualities of the watershed determine the discharge, sediment concentration and size of the sediment particles. These can be considered independent factors with respect to the channel. The dependent factors are then the channel width, depth, velocity and slope. Rugosity is a semi-independent factor, for it is governed both by the depth-particle size ratio and by sediment concentration. Under certain conditions the channel may inherit a slope and temporarily be forced to accommodate to it, but in geologic time slope finally tends to be adjusted to a mutual interdependency with other dependent factors.

Furthermore, the forces of erosion and deposition tend to adjust and readjust in response to local variations, and these checks or balances tend to create and maintain a quasi-equilibrium which characterizes nearly all channels. Though regime in natural channels is seldom completely fulfilled, it is closely approached. Even when a natural channel is aggrading or degrading, braiding or meandering, the hydraulic factors still tend to be nearly balanced, and divergence from regime is reflected in only small deviations from values of hydraulic factors which characterize regime conditions. As a result of these interactions, channels are similar and change in a similar manner if they have similar discharge and loads. A corollary to this is that one may judge the general character of discharge and load by inspection of the channel characteristics.

River pattern is defined as the plan view of the channel as seen from the air. There are three general types of patterns. The first is meandering, which is characterized by a relatively small value of width-depth ratio, as compared with other patterns of rivers having equal bankful discharge. The second is the braided pattern distinguished by many anastomozing channels separated by bars or islands. This pattern is typified by relatively large total width of water surface relative to mean depth as compared to other patterns at equal bankful discharge. Channels which are not divided by islands and do not meander may be called the "normal" pattern.

Comparing rivers of equal bankful discharge, braided patterns only occur when the channel gradient exceeds a given value, and meandering patterns when the slope is less than that same value. "Normal" patterns, however, can occur in either range of channel gradient.

Our own observations on natural rivers and experiments in the laboratory have led

us to conclude that the primary cause of river braiding is selective deposition. When the load introduced into the reach is relatively small in quantity, bed particles tend to move in a band over the centre of the channel, the width of the band increasing with increasing quantity of sediment introduced. When the load includes particles slightly too coarse to be kept in motion, these come to rest near the middle of the channel and in doing so trap or hide some of the finer particles.

By this process a central bar is gradually built up, which on the average is somewhat coarser than the mean of the introduced load. Despite the decrease of depth immediately over the central bar, velocity actually remains the same or increases somewhat at that place as a result of decreasing roughness over the bar, and the particles continue to move over the bar instead of in the deeper portions of the channel which flank the central bar. The building of the bar is also accompanied by increasing water surface slope. As the bar builds closer to the water surface, the velocity then decreases, bed sediment over the bar ceases, at which time the band of moving sediment is diverted into one of the deeper segments flanking the bar. At such a time essentially two channels exist separated by a bar which becomes an island when the water surface is lowered.

These central bars force the flanking channel to erode the channel boundaries with the result that discrete channels separated by islands are formed. The central bars grow by addition at their downstream ends and are often cut across by new channels as the process of channel shifting continues. The shifts often make separate channels rejoin, so the net result is a limited number of channels, continually dividing and rejoining.

That the slope of such a braided stream should be steeper than that for a single channel carrying the same total water and the same size of particles follows from the general consideration that channel slope tends to vary inversely as a power function of discharge.

Thus a channel becomes braided because of progressive deposition of the coarse portion of the debris load, and the slope of the braided channel generally is determined by the load and the flow pattern rather than vice versa.

Meandering on the other hand represents a condition in which there appears to be little segregation of particle size in the process of deposition, and there is less tendency for material to move in the centre of the channel. Central bars do not form. Deposition is primarily on the point bars on the convex bank of a channel in a bend.

Meanders tend to move downstream and the whole river wanders from one part of the flood plain to another. Because deposition is nearly equal to erosion, general aggradation occurs more slowly than in braided channels and the movements of the channel are, therefore, slower. In this sense the meandering pattern is more stable in that it can more easily be restricted within a given meander belt.

Meanders are formed by processes which occur in all channels, for the wave length of meanders is directly proportional to river width, and this proportionality also holds true for pools and alternate riffles which occur in all natural channels.

It is believed that meanders become developed only under certain combinations of width and velocity-depth ratios. If one considers the change in velocity, depth, and width downstream in most rivers at bankful stage, it will be noted that width increases as the square root of discharge as found by Lacey, depth increases as the 0·4 power of discharge and velocity increases as about the 0·1 power of discharge. The slope, however, tends to decrease as about the 0·4 power of discharge causing in general decrease in size of debris downstream. Thus decreasing slope and decreasing size of material downstream with a concomitant slight increase in velocity demonstrate that in general the load and discharge tend to govern the width, depth, velocity and slope rather than the velocity governing the load. The decrease of particle size downstream in a large river is the result of sorting of coarse particles from fine as well as breakage and abrasion. The depth increases downstream faster than velocity and this is one factor which tends to make a meandering pattern in downstream recahes of a river system.

Notes, Correspondence, News, Etc.

REPORT ON THE MULTIPLE-PURPOSE PLAN FOR PERMANENTLY CONTROLLING THE YELLOW RIVER AND EXPLOITING ITS WATER RESOURCES*

THE MULTIPLE-PURPOSE PLAN TO EXPLOIT the Yellow river proposes adoption of the following measures in all parts of the river basin where there has been loss of water and soil:

(A) MEASURES FOR FARMING TECHNIQUE

1. *Improvements in farming methods* — To enable soil to absorb more rain, the use of deep ploughing and hoeing between rows immediately after rain; to improve soil structure, the use of more fertilizer, crop rotation, and so on.

2. *To conserve water and soil* — To prevent rain water rushing down the sloping land, planting of crops in furrows following the contours and preparing such furrows on fallow land, and similar measures.

3. *To improve top-soil* — To be done by close-planting; planting crops (such as maize, sorghum and beans) in alternate parallel strips along slopes; laying our buffer grass belts between furrows; growing green-manure crops in summer fallow, rotating grass and other crops; growing fodder grasses; controlling grazing on pasture; and so on.

(B) AGRICULTURAL MEASURES FOR SOIL IMPROVEMENT

1. *On farmland* — Terracing fields on sloping land, banking cultivated slopes, ditching and banking along contour lines; laying out systems of ditches to collect and drain water, digging " dust-pan " storage ponds (terracing down the gullies), and so on.

2. Ceasing to cultivate the steeper slopes and planting them with trees and grass.

(C) AFFORESTATION MEASURES FOR SOIL IMPROVEMENT

1. Planting trees on the bottom and slopes of gullies, on river banks and beaches, on the banks of reservoirs and on alkaline land.

2. Planting of wind-breaks to fix shifting sand and protect farmland.

3. Enclosure of forested hills for natural afforestation, and afforestation of slopes and hilly areas.

(D) WATER CONSERVATION MEASURES FOR SOIL IMPROVEMENT

1. Banking heads or sides of gullies to prevent them extending.

2. Building check dams, silt-precipitation dams (to hold back silt and make it available for recovery as arable land), and huge earth dams.

3. Improvement of soil through recovery of silt (by conducting silt-laden water on to dyked plots and draining it off after its silt has settled).

4. Building small irrigation works.

5. Building storage ponds on slopes to hold back water and silt, and sumps to retain rain water.

TENG TSE-HUI
Vice-Premier of the State Council
of the People's Republic of China

*With acknowledgement to the State Council of the People's Republic of China.

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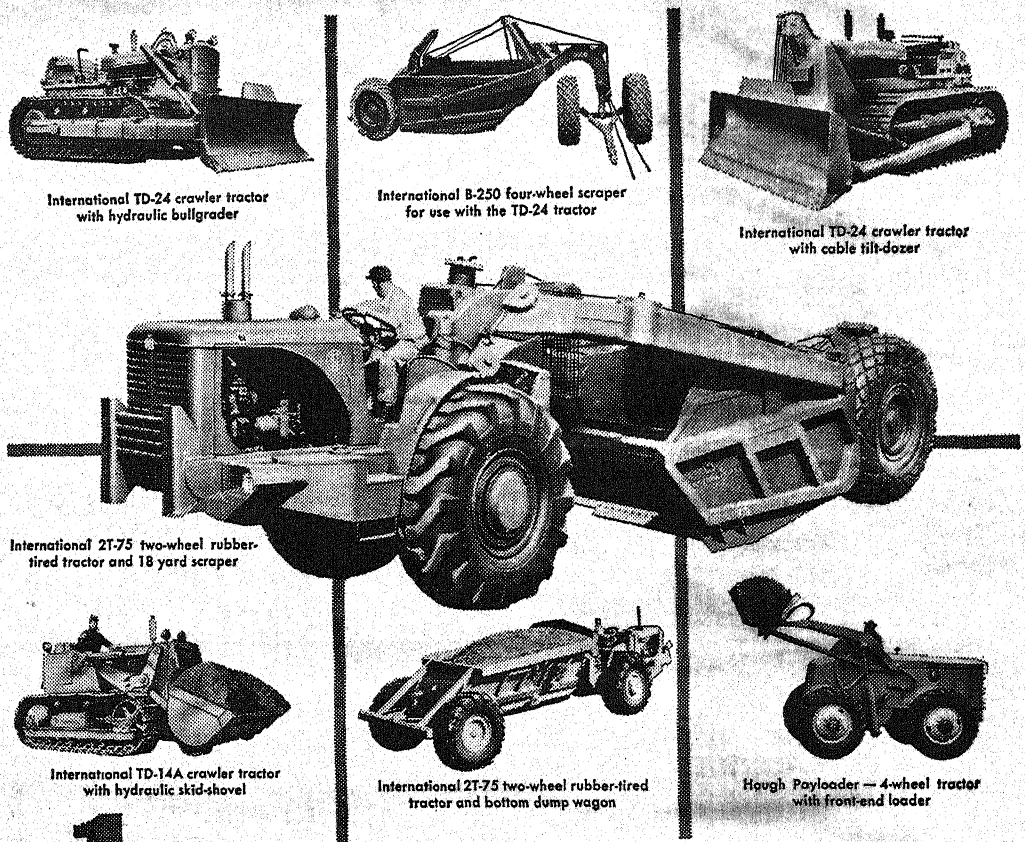

International TD-24 crawler tractor with hydraulic bullgrader

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International 2T-75 two-wheel rubber-tired tractor and 18 yard scraper

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